HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

Low carbon with a splash of justice: Role of experimentation in the Finnish built environment

Master's Programme in Environmental Change and Global Sustainability

Study Track:
Global Sustainability

Master's thesis

Author:
Saija Mokkila

Instructors:
PhD David Lazarevic
PhD Anne Toppinen

09/2022
Helsinki

HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

Tiivistelmä

Tiedekunta: Bio- ja ympäristötieteellinen tiedekunta
Koulutusohjelma: Ympäristömuutos ja globaali kestävyys
Opintosuunta: Globaali kestävyys
Tekijä: Saija Mokkila
Työn nimi: Kokeilujen rooli suomalaisessa rakennetussa ympäristössä
Työn laji: Maisterin tutkielma
Kuukausi ja vuosi: Syyskuu 2022
Sivumäärä: 59 s + liitteet 24 s
Avainsanat: asuminen, kunnat, kestävyysmuutos, kokeilut, rakennukset, vähähiilinen
Ohjaajat: PhD David Lazarevic, PhD Anne Toppinen
Säilytyspaikka: Helsingin yliopiston kirjasto, Viikki
Tiivistelmä: Tämän tutkielman tavoitteena oli systemaattisesti kartoittaa ja tarkastella rakennetun ympäristön vähähiilisyys- ja/tai sosiaalinen oikeudenmukaisuus kokeiluja Suomessa sekä ymmärtää, miten kunnat osallistuvat kokeiluihin ja millaisia haasteita kunnat kohtaavat siihen osallistuessaan. Oikeudenmukaisten ja vähähiilisten rakennusten ja asumisen muotojen selvittämiseksi kartoitettiin systemaattisesti 1 386 kohdetta 15 tietokannassa. 204 rakennetun ympäristön vähähiilisyys ja/tai oikeudenmukaisuus kokeilua tunnustettiin ja analysoitiin. Kuntien osallisuutta ja kohtaamia haasteita lähestyttiin tapaustutkimuksella neljästä suomalaisesta kaupungista (Helsinki, Joensuu, Turku ja Vantaa). 14 kokeilujen parissa työskentelevää henkilöä haastateltiin ja lisäksi kerättiin 1 839 sivua tapauskaupunkeihin liittyviä asiakirjoja. Haastatteluja ja dokumentteja analysoitiin abduktiivisesti kuntien osallisuuden tapojen ja kuntien edustajien kohtaamien haasteiden selvittämiseksi.

Tutkielman tulokset osoittavat, että kokeiluissa keskitytään niche-markkinoiden rakentamiseen ja kehittämiseen sekä teknologioiden testaamiseen. Keskittyminen sosiaaliseen oikeudenmukaisuuteen ja ihmisten käyttäytymiseen on vähäisempää. Vaikka kokeiluissa oli joitain päällekkäisyyksiä vähähiilisen ja sosiaalisen oikeudenmukaisuuden välillä, kokeiluilla ei pyritty lisäämään oikeudenmukaisuutta, vaan pikemminkin toteuttamaan vähähiilisyyttä sosiaalisesti oikeudenmukaisella tavalla. Kunnat keskittyivät voimakkaasti niche-markkinoiden rakentamiseen ja kehittämiseen, ja kokeilujen sujuvoittamiseen. Kunnat eivät juurikaan tehneet kokeiluja omassa toiminnassaan ja keskittyivät kokeiluprosessiin rakennetun ympäristön vähähiilisen ja oikeudenmukaisen siirtymän sijaan. Lisäksi näissä toimissa havaittiin heikosti uutuusarvoa, joustavuutta ja kykyä antaa kokeiluhankkeiden epäonnistua.

Tutkielmassa ilmenee myös, että kestävyyskokeilujen ja kestävyysmuutosten väliset yhteydet eivät ole niin suoraviivaisia kuin tutkimuksen viitekehys esitti. Vaikka useita havaintoja kestävän kehityksen kokeiluista tehtiin, on edelleen tarve lisätutkimuksille, jotta ymmärrettäisiin paremmin rakennetun ympäristön sosiaalisesti oikeudenmukaisten ja vähähiilisten kokeilujen ominaisuuksia ja kyettäisiin vauhdittamaan rakennetun ympäristön kestävyyssiirtymää.

HELSINGIN YLIOPISTO

Abstract

Faculty: Faculty of Biological and Environmental Sciences
Programme: Environmental Change and Global Sustainability
Study Track: Global Sustainability
Author: Saija Mokkila
Title: Low carbon with a splash of justice: Role of experimentation in the Finnish built environment
Level: Master's thesis
Month and year: September 2022
Number of pages: 59 pp. + appendices 24 pp.
Keywords: buildings, cities, experimentation, housing, low carbon, sustainability transition
Instructors: PhD David Lazarevic, PhD Anne Toppinen
Where deposited: Viikki Campus Library
Abstract: This thesis aimed to systematically map and review built environment low carbon and/or social justice experiments in Finland and understand how municipalities engage in experimentation and what challenges municipalities face when engaging in it. To find what forms of experiments for socially just low carbon buildings and housing can be found in Finland, 1 386 objects in 15 databases were systematically mapped. 204 unique built environment low carbon and/or social justice experiments were recognized and further reviewed. Municipality engagements and challenges in experimentation were approached through a case study of four Finnish municipalities Helsinki, Joensuu, Turku, and Vantaa. 14 case city officials and other persons working with experimentation were interviewed, and 1 839 pages of case-city-related documents were gathered. Triangulation was used to analyze the interview transcripts and additional documents in an abductive manner to find what kind of policy engagements for experimentation municipalities participated in and what kind of challenges the municipality representatives identified when doing so.

This thesis discovered that there is a large focus on building and nurturing niches and testing technologies with a lack of focus on profound social justice and the behavioral side of the sustainability transitions. The sustainability experimentation in the built environment was technology-focused and lacked profound social justice aspects. Even though there were some overlaps between low carbon and social justice in the experiments, the experiments did not seek to increase social justice but rather to do low carbon in a socially just way. Municipalities strongly focused on building and nurturing niches and experimentation as a process. Municipalities did not do much experimentation in their operations and focused on the experimentation process rather than the subject matter. Also, the municipality experimentation engagements were characterized by a lack of novelty, flexibility, and uncertainty.

This thesis also reveals that the links between sustainability experimentation and sustainability transitions may not be as straightforward as the scientific models and frameworks present. Though this thesis made several findings about sustainability experimentation, there remains a particularly urgent need to develop and conduct additional studies. They are needed to understand better the phenomena in the socially just low carbon experimentation in the built environment to enable just transition to low carbon buildings and housing.

HELSINGIN YLIOPISTO

Table of contents

1 Introduction

Buildings and housing are major sources of energy use and greenhouse gas (GHG) emissions. In the European Union (EU), buildings are responsible for approximately 40 % of energy usage and 36 % of GHG emissions. Roughly 75 % of the EU's building stock is energy inefficient. (EC, 2021.) On the other hand, buildings have a relatively high energy saving potential (Forsström et al., 2011), and GHG emission reductions can be achieved relatively cost-efficiently (IPCC, 2014) compared to other sectors. These factors have attracted significant policy attention to buildings (e.g., EU, 2018), and decarbonizing buildings has become an important way to move toward achieving the EU's climate change mitigation targets of a 55% reduction in GHG emissions by 2030, compared to 1990 levels (EC, 2019).

This decarbonization requires widespread adoption of low-carbon solutions (Heiskanen et al., 2017). The range of solutions include technologies such as renewable power generation (Heiskanen et al., 2017) and low embodied energy materials (Cabeza et al., 2013), new business and organizational models, and specific areas for experimentation (such as living labs) (Heiskanen et al., 2017). The solutions also include those related to behavioral change (Abrahamse et al., 2005), policy (Chen et al., 2019) and governance (Kivimaa et al., 2017). These solutions need experimentation before they can be extensively adopted (Schot & Geels, 2008). Experiments are implemented to determine how solutions can be implemented in real-life situations (Heiskanen et al., 2017).

In addition to the need to test new technologies in their implementation context, there are other reasons to experiment. The experiments also acquire technological, social, and institutional lessons relevant to transform unsustainable systems (Sengers et al., 2019). For example, since the end of 2020, the EU has required all new buildings to be nearly zero energy buildings (EU, 2010), which would not be possible without previous experiments on low carbon technologies (e.g., Ornetzeder & Rohracher, 2009). In the coming years, legislation will most likely demand more from the energy performance of buildings as the EU strives to move towards more ambitious emission reduction objectives (EU, 2010). For example, preparing regulation that extends the energy efficiency requirements from new construction to renovations is in progress in Finland (Prime Minister's Office, 2021). This requires experimenting with new solutions and even more comprehensive utilization of low carbon technologies.

Furthermore, the transition to low carbon buildings and housing requires not only experimentation but significant transformative changes in the built environment, economy, and

society that are likely to have uneven impacts. With this in mind, it is essential to note that critical housing stock regarding climate change mitigation is often inhabited by the most vulnerable social groups (Portal et al., 2021). Hence, it is crucial that low carbon solutions also address equitability and social justice concerns (cf. Sovacool & Dworkin, 2015). Indeed, the EU's Green Deal has brought focus to the concept of a just transition, with an aim to "ensure that the transition towards a climate-neutral economy happens in a fair way, leaving no one behind" (EC, 2019). This EU-level guidance directs the member states to take socially just national and local actions towards low-carbon solutions.

The importance of experimentation has also been recognized in Finland. For example, the 2015 Cabinet of Finland specifically promoted experimental culture for finding solutions (Prime Minister's Office, 2015), and previous governments have talked about experimentation (Rimpelä, 2017) as well. Several experiments, from small-scale experiments to pilot clusters and strategic experiments, have taken place in Finland since at least the 1970s (Antikainen et al., 2019). Since then, research on experiments and experiment evaluations have been performed, and suggestions for improvement in experimentation have been proposed (e.g., Annala et al., 2015; Heiskanen et al., 2017; Laakso et al., 2017). In these efforts, the lack of systematic evaluation of the experiments has been recognized as a limiting factor in the utilization and distribution of the experiment results (Stenvall, 2017). This may hinder disseminating the experiment results, cripple facilitating sustainability transitions, and even slow the achievement of Finland's ambitious carbon neutrality targets (see Finnish Government, 2019).

There is much focus on experimentation at the municipal scale. This includes a focus on, for example, the specific areas for experimentation that can be provided in the urban environment (e.g., Heiskanen et al., 2017) and the municipality role in experimentation (e.g., Kronsell & Mukhtar-Landgren, 2018). Despite this focus, the practical challenges that municipalities face when trying to support experimentation are less known. There is also a gap in the research on how actively municipalities engage in experimentation.

This thesis aims to systematically map and review built environment low carbon and/or social justice experiments in Finland and understand how municipalities engage in experimentation and what challenges municipalities face when engaging in it. Understanding the municipality engagement and challenges is approached through a case study of four Finnish municipalities (Helsinki, Joensuu, Turku, and Vantaa). This thesis answers the following research questions:

1. *What forms of experiments for socially just low carbon built environment can be found in Finland and the case municipalities in particular?*
2. *What kind of policy engagements for experimentation do municipalities participate in, and what challenges do representatives of municipalities identify when engaging in them?*

This thesis is structured as follows. In Section 2, the conceptual and empirical background and theory are presented. Section 3 explains the research approach, and Section 4 presents the findings of the thesis. In Section 5, findings are discussed, and conclusions are provided.

2 Literature review and analytical framework

This section begins by introducing the key concepts in Section 2.1. Section 2.2 presents the conceptual and Section 2.3 empirical background and theory.

2.1 Key concepts

This thesis draws its theoretical basis from sustainability transitions (Section 2.1.1), experimentation (Section 2.1.2), and experimentation in sustainability transitions (Section 2.1.3).

2.1.1 Sustainability transitions

Transitions are long-term (25-50 years) holistic processes. Transitions are co-evolutionary processes engaging multiple actors to rearrange the institutional, organizational, and material arrangements of socio-technical systems. (Markard et al., 2012.) Socio-technical systems are a series of semi-coherent and linked rules whose alignment gives socio-technical system stability "and 'strength' to coordinate activities" (i.e., socio-technical regime) which also includes society's complex infrastructures and actor networks (e.g., Kemp et al., 1998; Schot & Geels, 2008). Socio-technical systems contain technological, material, organizational, institutional, political, economic, and socio-cultural aspects (Geels & Schot, 2007). Socio-technical transitions contain fundamental changes in the operations that provide core societal functions (for example, arranging energy, water, mobility, and housing) to more sustainable modes of consumption and production (Markard et al., 2012).

Before a sustainability transition can occur, novel solutions must be developed at a smaller scale (Schot & Geels, 2008). According to transition scholars, the concept of the niche responds to this demand as a protective domain for new socio-technical innovations. Niches are specific spaces for path-breaking innovations and provide a domain where these innovations

can develop. They protect against the selection pressure of the regular market environment, which allows actors to learn about innovations and ways to use them. (e.g., Markard et al., 2012.)

There are different pathways for sustainability transitions. In all these, niches gather internal momentum by aligning and stabilizing. Increasing landscape pressure creates windows of opportunities for niches to break into the regime through, for example, the niche's momentum or some specific landscape shock. (Geels & Schot, 2007.)

The momentum to challenge the well-established unsustainable socio-technical regimes can be achieved through a process of social learning in a variety of (niche) experiments. Experimenting makes articulating promising expectations, engaging different actors, and gaining broad advocacy more attainable. (e.g., Geels & Raven, 2006; Markard et al., 2012.)

2.1.2 Role of experimentation in transition

Experimentation has been defined in several ways, according to Table 1. Different disciplines and scholars have emphasized diverse aspects, and an exhaustive, all-encompassing definition of experiment and experimentation does not exist (Hildén et al., 2017).

The definitions in Table 1 also have some common determinants. Experiments are specified as testing or trying out something novel and concrete in a specific environment. In the experiment, setting, time, space, scope, and/or actors have been limited. Aims to provide proof of principle and conditions of uncertainty have also been recognized as experiment characteristics.

Table 1

Definitions for experiments and experimentation

Concept	Definition	Source
Urban climate change experiments	Aim to challenge dominant institutions and existing sources of authority	Bulkeley & Castán Broto (2013)
Sustainability science	Intervention to create empirical evidence of some form	Caniglia et al. (2017)
Sustainability experimentation	Experience from field trials, demonstrations, pilot projects, and experiments	Heiskanen et al. (2017)
Legal design	An instrument for facilitating collective effort	Heldeweg (2017)
Climate change solutions	An initiative that differs from currently established practices	Hildén et al. (2017)
Policy sciences	A venue for detailed and rewarding interplay between science and policy	McFadgen & Huitema (2018)
Sustainability transitions	Inclusive initiative based on practice and led by challenge, designed to further system innovation through social learning with conditions of ambiguity and uncertainty	Sengers et al. (2019)
Strategic niche management	Creation of spaces to shield, nurture, and partially empower niche innovations	Smith & Raven (2012)
Policy experimentation	Temporary, reversible, adaptable, and evidence-based approach to policymaking	Tassey (2014)

The shared experimentation factors (derived from the literature presented in Table 1) have also some common determinants. Experiments are specified as testing or trying out something novel and concrete in a specific environment with limited setting, time, space, scope, and/or actors. Aims to provide proof of principle and conditions of uncertainty have also been recognized as experiment characteristics. These common factors determine how this thesis sees experimentation. In this thesis, experimentation refers to gaining early experience in field trials, demonstrations, pilot projects, and experiments (Heiskanen et al., 2017). Experiments are seen as testing something novel with a distinct setting, time, space, scope, and/or actors.

2.1.3 Experimentation in sustainability transitions

Experimentation is a key theme in sustainability transition literature (e.g., Markard et al., 2012; Sengers et al., 2019). It is essential for testing out new novelties in niches to enable large-scale transitions (Schot & Geels, 2008). Experimentation can aim to isolate causality, enhance systemic innovation or generate new solution concepts (Ansell & Bartenberger, 2016).

Much experimentation has focused on testing new technologies (e.g., Heiskanen et al., 2017), with policy experimentation becoming a recent topic of inquiry (Ghosh et al., 2021). Experimentation has been introduced as a vital way for governance to drive sustainability transitions, allowing the development and testing of innovative governance solutions (Kivimaa et al., 2017). Experimentation in the transition literature has focused mainly on creating protected spaces for experimentation and building and nurturing niches around them (e.g., Ghosh et al., 2021). Experiments have been justified by their ability to improve the evidence base (Sanderson, 2002) and reversibility (Tassey, 2014) of policy interventions. To address multidimensional and complex challenges (such as climate change and growing inequality), experimentation is claimed to be a better-suited approach than more common ways of governance (e.g., Castán Broto & Bulkeley, 2013; Ghosh et al., 2021).

2.2 The research gaps

This section scrutinizes prior studies of low carbon and social justice experimentation in the built environment (Section 2.2.1) and further looks at the role of municipalities as intermediaries in experimentation (Section 2.2.2) to establish the research gaps further.

2.2.1 Low carbon and social justice in built environment experiments

Prior studies on low carbon experiments in the built environment have focused on, for example, experiment types (e.g., Kivimaa et al., 2017), functions (Laakso et al., 2017), funding (e.g., Annala et al., 2016), impacts (e.g., Berg et al., 2014), learning (e.g., Heiskanen et al., 2017),

and participation (e.g., Seppälä et al., 2017). The studies addressing the types of low carbon in built environment experiments have concentrated mainly on single technologies (e.g., Heiskanen et al., 2015) and have failed to explore systematically (e.g., Cabeza et al., 2013) the ways experiments address carbon emissions. The difficulty in comparing and systematically reviewing published data has resulted from the difficulties in measuring energy consumption in construction projects and from the lack of uniform methods (Cabeza et al., 2013).

Social justice, as a greater concept than just participation, has been found to be a rarely evaluated aspect of experimentation (Antikainen et al., 2017). The literature review of this thesis found only one study that focused on social justice and low carbon housing. Castán Broto (2012) did a case study in a Slovenian municipality studying low carbon transitions in the context of social housing. For these reasons, this thesis has looked outside experimentation studies to find an applicable framework to categorize the ways experiments address the dual issues of low carbon and social justice. These specific concepts have been combined with the transition literature to form the analytical framework to address the first research question. This framework is presented in detail in Section 2.3.1.

2.2.2 Role of municipalities as intermediaries in experimentation

There is a firm focus in the literature on experimentation in cities and at the urban scale. In prior studies, cities have been recognized to play a key intermediary role in experimentation and sustainability transitions (Fuenfschilling et al., 2019). Kivimaa et al. (2019) have defined transition intermediaries as "actors and platforms that positively influence sustainability transition processes". This is done to aid the socio-technical transition, create new cooperation, and disturb unsustainable systems by connecting actors, activities, skills, resources, visions, or demands. (Kivimaa et al., 2019.) According to Fuenfschilling et al. (2019), there is an increased urgency for sustainability transitions in cities due to, for example, high energy consumption in cities. Cities have also brought many current sustainability initiatives and interventions forward (Fuenfschilling et al., 2019).

Whilst attention has focused on the role of the municipalities (and their administrative units) as intermediary actors in experimentation (e.g., Matschoss & Heiskanen, 2017), the diversity of municipalities' engagements for experimentation (see Schot et al., 2019) has been less known. Schot et al. (2019) have defined experimental policy engagements (EPEs) to depict "the diverse ways in which policymakers engage with the process of societal experimentation for sustainable transformation". This includes "initiating, supporting or mobilizing and

evaluating such initiatives for informing decision making, enabling a process of social learning, developing alternative pathways and enacting desirable futures" (Schot et al., 2019).

EPEs have primarily focused on creating protected spaces for, and facilitating, niche innovations. However, experimentation has been recognized to be also relevant for scaling up, and regime destabilization (Schot et al., 2019) and can be used in addressing the repercussions of regime destabilization and coordinating multi-regime interactions (Kanger et al., 2020). For these reasons, this thesis has chosen the transformative outcome framework (Ghosh et al., 2021; Schot et al., 2019) that allows for an investigation of the diversity and depth of the municipalities' EPEs and challenges to address the second research question. This framework is presented in Section 2.3.2.

2.3 Analytical Framework

Section 2.3.1 presents the analytical framework used to answer the first and Section 2.3.2 the second research question.

2.3.1 Categorizing socially just low carbon experiments

To answer the first research question, there is a need to understand the forms of experimentation and how they engage with climate change mitigation and social justice. Hence to capture the variety of experimentation in the built environment, this section presents three different aspects of experimentation that each require different frameworks for categorization. Section 2.3.1.1 presents the empirical background for categorizing experiments. After that, empirical background for categorizing the ways experiments engage with low carbon (Section 2.3.1.2) and social justice (Section 2.3.1.3) are presented.

2.3.1.1 Categorizing experiments

To categorize experiments, researchers have developed several categorizations. Divisions have been made based on, for example, logic (e.g., Ansell & Bartenberger, 2016; Sengers et al., 2019) and outcomes (e.g., Heiskanen et al., 2017; Kivimaa et al., 2017) of the experiments. Table 2 presents the variety of concepts and categories used to categorize experiments.

Kivimaa et al. (2017) presented an experiment classification that differentiates between the varied purposes of experiments and further expanded the understanding of the variety in experimenting. This logic is used as an analytical framework in this thesis as it (a) addresses the spatial scale, setting, and focus of the experiments, (b) interprets the outputs and outcomes the experiments generated, and (c) is based on a systematic review of energy and built environment transitions research this thesis also aims to address. The chosen framework

is presented further below. Table 3 presents different experimentation types, from niche creation to societal problem-solving and change. According to Kivimaa et al. (2017), the spatial scale of these experiment types runs from local to regional, national, and even broader. The experiment settings vary from protected niche (niche creation) to several niches (market creation), and to concrete use of space and land (spatial development) as well as from single policy (market creation) to larger policy level (societal problem solving and change). Niche and market creation experiments focus on a single sector, and spatial development and societal problem solving and change experiments have a more cross-sectoral focus. (Kivimaa et al., 2017.) Types of change that the experiments generated are presented in Table 4.

Table 2

Different approaches for categorizing experiments

Concept	Categories	Source
Ecological Economics	Choice and valuation experiments, willingness-to-accept/willingness-to-pay experiments, common pool resource experiments, simulation modeling experiments, auction experiments	Ansell & Bartenberger (2016)
Experimentation logics	Controlled experimentation, Darwinian experimentation, generative experimentation	Ansell & Bartenberger (2016)
Sustainability performance	Environmental target experiments, economic target experiments, social performance target experiments	Antikainen et al. (2019)
Aims and purposes	Feasibility testing, feedback and knowledge development, skill and capacity development, new network and community development, reflective learning, communication and promotion, participant and policy maker inspiration, existing structure and practice challenging, improved environments and infrastructures development	Heiskanen et al. (2017)
Learning	Tecno-scientific and cognitive learning, situated learning	Heiskanen et al. (2017)
Competence development	Low-carbon technology evaluation; built environment low-carbon integration; usability and system interfaces; business mainstreaming practice integration; public administration practice integration; communication, marketing, and service design	Heiskanen et al. (2017)
Low carbon technology trial database	Local government experimentation, built environment experimentation, mobility experimentation, new purchasing and business model experimentation, traditional company experimentation	Heiskanen et al. (2017)
Experiment type	Niche creation, market creation, spatial development, societal problem solving, and change	Kivimaa et al. (2017)
Experiment generated change	Changed discourse, new technology, built environment or infrastructure change, policy and institutional change, new business practices, new market or market change, new consumer/citizen practices	Kivimaa et al. (2017)
Policy Science	Technocratic experiment, boundary experiment, advocacy experiment	McFadgen & Huitema (2018)
Type of experiment	Governance experiment, organizational experiment, product experiment, service experiment, social experiment, system experiment	Matschoss & Repo (2018)
Sustainability transitions	Niche experiment, bounded socio-technical experiment, grassroots experiment, transition experiment, sustainability experiment	Sengers et al. (2019)

According to Kivimaa et al. (2017), the change that the experiments generated included outputs (such as new goals, strategies, designs, and instruments) and outcomes (e.g., initiating socio-technical change in practices). Some outputs and outcomes were focused on aspects of learning, and some, on the other hand, were substantive. The learning-focused outcomes and outputs were: (a) changed discourse, (b) policy and institutional change, and (c) changed consumer or citizen practices. The substantive outputs and outcomes were (a) new technology, (b) built environment and infrastructure change, (c) new business practices, and (d) new market or market change. (Kivimaa et al., 2017.)

Table 3

Experimentation types (modified from Kivimaa et al., 2017)

Type of experimentation	Description
Niche creation	Testing technology and creating innovation around it (local)
Market creation	Stimulating new markets or changing market conditions into sustainable technologies favoring market conditions (regional, national or broader)
Spatial development	Generating long-term spatial development with sustainability benefits with concrete use of space and land (local or regional)
Societal problem solving and change	Solving large-scale problems and supporting the change process at a policy level (local, regional or national)

Table 4

Types of change that the experiments generated (modified from Kivimaa et al., 2017)

Type of change	Outputs	Outcomes
Changed discourse	Production of a new vision on the integration of previously detached discourses	Changes in the shared visions, new narratives, improved cognitive understanding
New technology	Practical applications of new technologies	Wider replication of successful technology experiments
Built environment or infrastructure change	Temporary changes in land use planning concerning energy-efficient housing and town planning, the building of a low carbon infrastructure	Insights on achieving broader changes
Policy and institutional change	Introduction of new spatial and district planning practices for enhancing eco- and energy efficiency, regionalization of previously local policymaking, using local actors in policy-making, and the development of the role of the public actors	New political spaces, governance rules, and practices
New business practices	Introduction of novel business models, often combining product and service (maintenance)	Changing business practices, increase in new businesses or jobs
New market or market change	-	The emergence of new markets, maintenance, and development of markets
New consumer/citizen practices	Citizen engagement in local communities as operators and providers of solutions and services; alternative communities diverting from mainstream	Altered energy consumption practices, energy saving as a way to reduce economic hardship

2.3.1.2 Categorizing low carbon solutions

Solutions to decarbonize the built environment include a variety of technology-centered efforts to decouple economic growth and consumption from GHG emissions (Reid & Houston, 2013), as well as organizational means. Low carbon efforts in the built environment can be arranged based on the stage of the building's life cycle where energy usage is attempted to curtail (Dixit et al., 2012; Kalaiselvam & Parameshwaran, 2014). This logic is used as an analytical framework in this thesis as it (a) is specific for buildings, (b) takes the whole building life cycle energy into account, and (c) can provide concrete information about the solution types.

According to Dixit et al. (2012), the life cycle energy of buildings includes embodied and operational energy. Embodied energy depicts the energy sequestered in building materials and buildings through the whole life cycle of a building. Operational energy represents the energy dispensed in operating the building. (Dixit et al., 2012.) Embodied energy is the energy exhausted in the measures of producing building materials, delivering them on-site, constructing, doing maintenance, renovating, and finally deconstructing the building (Dixit et al., 2012). The operational energy of a building is influenced by energy design, passive component use, insulation/air tightness, building services, renewable energy use, energy management (Kalaiselvam & Parameshwaran, 2014), and household energy consumption practices (Abrahamse et al., 2005). These factors are described further in Table 5.

Table 5

Total life cycle energy in buildings (modified from Abrahamse et al., 2005; Dixit et al., 2012; Kalaiselvam & Parameshwaran, 2014)

Type	Subtype	Description
Embodied energy	Building material production	Initial embodied energy consumed offsite in the production of materials and components, including raw material procurement
	On-site delivery	Finished product transportation to the site
	Construction	Initial embodied energy consumed onsite during the construction
	Maintenance	Recurrent embodied energy used in the maintenance process during the useful life of a building
	Renovation	Recurrent embodied energy used in the refurbishment process during the useful life of a building
	Final demolition	Energy expended in the process of deconstruction of a building and building material disposal
Operational energy	Energy design	Energy efficiency design with end-usage in mind
	Passive components	Architectural form and the materials used to provide building services like heating, ventilation, cooling, and heat storage
	Insulation/air tightness	Reducing unwanted heat losses or gains through effective insulation and/or air tightness
	Building services	Energy efficient building services
	Use of renewable energy	Use of renewable energy sources in building services
	Energy management	Efficient monitoring, management, and use of a building and its services
	Energy behavior	Energy consumption behavior of households/building users

According to Kalaiselvam and Parameshwaran (2014), in the operational energy of a building, energy design should be considered first. Then what cannot be addressed through the design should be looked at through the use of passive components and so on. At the end, renewable energy should be used for energy consumption that cannot be eliminated, and even then, the energy use should be managed. (Kalaiselvam & Parameshwaran, 2014.)

2.3.1.3 Social justice categories

Sovacool and Dworkin (2015) have utilized existing concepts from justice, philosophy, and ethics and applied them to energy transition. This conceptualization is used as an analytical framework in this thesis as it (a) implements multiple key disciplines, (b) integrates obvious distributive and procedural justice concerns, and (c) can be easily applied to experiments in a built environment. The framework consists of eight justice categories that range from injustices from inefficiencies and lack of access to consent and human rights (Sovacool & Dworkin, 2015). These justice applications are presented further in Table 6.

Table 1

Justice applications (modified from Sovacool & Dworkin, 2015)

Topic	Applications	Injustices
Efficiency (virtue)	High penetration and availability of efficient service	Inefficiencies involved in the supply, distribution, and end-use
Externalities (utility)	Less suffering, pain, externalities, and disasters associated with the production and use	The imposition of negative social and environmental costs on society
Human rights and social conflict (human rights)	An obligation to protect human rights in the production and use	The violation of civil liberties
Due process (procedural justice)	Free prior informed consent and fair representation in decision-making	Approaches that ignore or contravene free, fair, and informed consent and/or do not conduct adequate social and environmental impact assessments
Accessibility and subsistence (welfare and happiness)	A system that gives people an equal shot of getting the service they need, systems that generate income and enrich lives	Lack of access or affordability
Subsidies (freedom)	Energy decisions not unduly restricted by government intervention	Subsidies involving involuntary wealth transfer to recipients
Resource egalitarianism (posterity)	An obligation to minimize resource consumption and ensure adequate reserves for future generations	Exhaustion of reserves
Intergenerational equity (fairness, responsibility, and capacity)	An obligation to protect future generations from energy-related harms	Negative impacts of climate change

2.3.2 Transformative outcomes framework

This section presents the empirical background for assessing experimentation and experiment-related challenges through transformative outcomes. Sustainability transitions literature suggests that the sustainability transformation of a socio-technical system is a result of an interaction between three processes. These processes are (1) successful niche building, (2) niche expansion, and (3) regime destabilization and opening up. These processes, that function parallel to each other or in sequences, all require experimentation and are essential for a successful transformation. (Schot et al., 2019.) Ghosh et al. (2021) have introduced twelve transformative outcomes across these macro-processes (with each macro-process having four outcomes). Transformative outcomes are changes in the properties and rules of socio-technical systems. They can be induced with EPEs and may influence sustainability transformations when combined. Transformative outcomes can be used to guide intervention and evaluation of EPEs toward a more transformative direction. (Ghosh et al., 2021.)

The transformative outcomes in building and nurturing niches are (1.1) shielding, (1.2) learning, (1.3) networking, and (1.4) navigating expectations. Shielding means constructing circumstances for niche innovations to prosper by railing off incumbent interests. (Ghosh et al., 2021.) The shielding can be active (direct support for niche innovations such as R&D) or passive (pre-existing conditions such as remote locations) (Smith et al., 2014). Learning refers to the cognitive practice of "knowing, understanding, and reflecting" (Ghosh et al., 2021). It is recognized as a core function as continuous learning is required to enable innovation (e.g., Schot & Geels, 2008). Networking means the transition actors' actions of complementing and enhancing each other's skills, knowledge, and capabilities through interacting, sharing ideas, exchanging resources, and working together (Avelino et al., 2020). Navigating expectations means steering the diverse expectations of networks to enable shared and inclusive future visions (Ghosh et al., 2021).

The transformative outcomes in expanding and mainstreaming niches are (2.1) upscaling, (2.2) replicating, (2.3) circulating, and (2.4) institutionalizing. Upscaling is the process of more users accepting the niche innovation and the niche rules. Replicating means expanding the niche geographically by reproducing similar niche spaces in different contexts. Circulating is sharing niche elements such as ideas, people, or learnings between multiple niches in different contexts. Institutionalizing is the process of making shared niche rules to be permanent. This means that the former niche rules become the new regime rules. (Ghosh et al., 2021.)

Table 7

Experimental policy engagements and related dilemmas (modified from Ghosh et al., 2021; Schot et al., 2019)

Macro process	Transformative outcomes	Experimental policy engagements contribution	Examples	Related dilemmas
1. Building and nurturing niches	1.1 Shielding	Protecting niche experiments	Innovation subsidies	Regulations can make shielding difficult or impossible
	1.2 Learning	Inducing learning in niche experiments	Knowledge gathering	Learning may not result in any change
	1.3 Networking	Creating collaboration opportunities	Networking platforms	Engaging a large group of people may slow down the process
	1.4 Navigating expectations	Paying attention to and appraising expectations	Transition arena	The long-term sustainability of the solution is often uncertain
2. Expanding and mainstreaming niches	2.1 Upscaling	Increasing user adoption	User club and platform	The instrumental and technology-focused way may not suit everything
	2.2 Replicating	Replicating experiments in other contexts	Funding for replicating	It is not always straightforward as context-specific adjustments are required
	2.3 Circulating	Promoting circulation between niches	Centralized coordination	Fluid circulation can be challenging to advance concretely
	2.4 Institutionalizing	Mainstreaming the rules of the niche among niche actors	Creating standards	The ideal time is challenging to set, and any attempts may succeed or fail
3. Opening up and unlocking regimes	3.1 De-aligning and destabilizing	Challenging existing systems through disruptive governance	Phase out policies	Influence is dependent on a range of factors that may be difficult to influence
	3.2 Unlearning and deep learning in regimes	Facilitating unlearning and deep learning among regime actors	Organizing policy lab	Unlearning and deep learning can require new organizational and administrative structures
	3.3 Strengthening regime–niche interactions	Creating linkages between niche and regime actors	Impact investment tool	Connecting to many niches limits resources to and knowledge about a particular niche
	3.4 Changing perceptions of landscape pressures	Challenging perceptions about landscape pressures of diverse groups of regime actors	Organizing foresight activities	Doubts about promoting and socializing particular views and lobbying for them

The transformative outcomes in opening up and unlocking regimes are (3.1) de-aligning and destabilizing, (3.2) unlearning and deep learning, (3.3) strengthening regime-niche interactions, and (3.4) changing the perceptions of landscape pressures. The de-aligning and destabilizing the regime includes the abandonment of regime-forming actions, assumptions, and values by regime actors. Unlearning refers to regime actors unlearning dominant rules.

Deep learning is learning that, through experiential social learning, increases the regime actors' system knowledge and readiness, desire, and capability to change the system. Strengthening regime-niche interactions means creating ways for niches and other regimes to interact. Changing perceptions of landscape pressures means changing the long-term trends that influence the way, direction, and speed systemic transformations unfold. (Ghosh et al., 2021.)

This logic is used as an analytical framework in this thesis as it (a) focuses on the transformative process, (b) also includes regime destabilization and opening up that has rarely been attached to experimentation (Schot et al., 2019), and (c) addresses the phase, outcomes and challenges of the experiments. The framework is presented further in Table 7.

3 Materials and methods

This section describes the materials and methods used to answer the research questions. Section 3.1 addresses the first and Section 3.2, the second research question. Section 3.3 assesses the validity and reliability of the materials and methods.

3.1 Experiment mapping

A mapping of Finnish experiments was carried out between December 2021 and January 2022. The mapping was collected from several databases (Appendix A) of Finnish experiments, demonstrations, pilot projects, and field trials. 1 386 objects in 15 databases were identified and reviewed. Internet searches were used to identify possible cases not found in the databases. In the searches, key search words for experiments were paired with building, housing, low carbon, and case city related words (see Appendix A for detailed description). 204 unique low carbon and/or social justice experiments in the built environment were recognized and gathered from these cases (see Appendix B for a list of all recognized experiments). Cases were recognized as experiments based on (a) project descriptions describing the experimental nature of the case, (b) previous study on Finnish experiments (see Heiskanen et al., 2017), or (c) recognition that a novel solution had been applied in the case (see Appendix A for a detailed description of the process).

In the recognized experiments, background information was analyzed to give more detail to the context in which the experiment unfolded. This included the experiment timing (Appendix C), location (Appendix D), stakeholders (Appendix E), and building types (Appendix F). The classification was based on preset categories that were complemented when the analysis of the experiments revealed missing but possibly essential categories. In this study, a choice was made to just look at these aspects as context and background material for

answering the first research question. It was acknowledged that the whole research could have been done by analyzing this information alone.

To answer the first research question, qualitative descriptions of experiments were analyzed further based on the analytical framework for categorizing experiments (presented in Section 2.3.1). Experiment type and the change that the experiments generated were reviewed (see Section 4.1.2 for results), and the type of low carbon and social justice were reviewed (see Appendix G) and analyzed (see Section 4.1.5 for results). The decision process was done individually for each category and experiment to determine these types.

3.2 Municipal level application

The second research question was approached through a lens of four Finnish municipalities. Helsinki, Joensuu, Turku, and Vantaa were the cities that agreed to be part of the research project. All the cities are large Finnish municipalities and represent different types of cities. The capital, Helsinki, with a population of 658,000 (Official Statistics of Finland, 2022), is the biggest city in Finland and can be perceived as a forerunner in experimentation in Finland. Vantaa, located next to Helsinki, represents a smaller city in the metropolitan area with a population of 239,000 (Official Statistics of Finland, 2022). Turku and Joensuu represent large cities outside the metropolitan area Turku with a population of 195,000 in western and Joensuu with a population of 77,261 in eastern Finland (Official Statistics of Finland, 2022). Though a relatively big city, Joensuu is more rural than other case cities. Even though four different municipalities were included in this study, the purpose is not to do a comparative case study.

Eleven semi-structured interviews (Gillham, 2005) with a total of 14 interviewees were conducted in the case cities (Table 8) between August 2021 and December 2021. City-related websites were reviewed to identify desirable interview targets. Inquiries were made to ask city contact persons to identify suitable interviewees in the city administration. Interviewees were likewise asked if they could identify any possible interview targets.

The 14 interviewees included city officials working with experimentation in the city administrations and other persons working with the city and experimentation (Table 8). An interview guide was used to direct the interviews (see Appendix H for the complete guide and rationale behind it). Interviews focused on (a) the types of experimental policy engagements cities undertake, (b) the challenges cities face when engaging in experimental governance, (c) the types of transformative outcomes experimental policy engagements target, and (d) the challenges governance experiments face beyond niche construction. The interviews were recorded and transcribed.

Table 8

Breakdown of interview and documentary data from case municipalities

Municipality	Interviews			Documents	
	Number	Interviewees	Total minutes	Number	Total pages
Helsinki	3	6 (H1–6)	132	20 (H7–H26)	898
Joensuu	2	2 (J1–2)	72	3 (J3 – J5)	86
Turku	3	3 (T1–3)	115	12 (T4–T14)	627
Vantaa	3	3 (V1–3)	129	19 (V4–V22)	611
Total	11	14	448	49	1839

Interviews were complemented with case city related document material. Documents were gathered by interviewee recommendations and internet searches. Internet searches were done to identify case city related municipal strategy, experimental policy engagement, low carbon, and social justice related documents (see Appendix I for a detailed description of the process). As a result, 49 municipal documents focusing on climate strategy, EPEs, low carbon, and social justice were compiled. From the documents, relevant parts were recognized for analysis (see Appendix I for a detailed description of the process). Table 8 presents the data used in the case study (see Appendix I for a detailed list of all the materials). Interview transcripts and the documents were analyzed further based on the literature review (presented in Section 2.3.2).

The interview and additional documentary data in this thesis were analyzed using the content analysis method. Content analysis involves analyzing the data by breaking it down and looking for similarities and differences. Content analysis is used to form a summary description of the phenomenon under study. Qualitative content analysis was carried out in an abductive manner. This meant that the analysis was facilitated by preset literature-based categories but not restricted by them. New categories related to the studied phenomenon were added when they emerged from the data. (Silvast, 2014.)

To facilitate the analysis, NVivo, a qualitative research analysis software, was used to organize and classify the textual material. Both the interview and document data were categorized in NVivo using preset categories derived from the chosen analytical framework. Categories were added when the analysis of the data revealed missing but possibly important categories (see Appendix J for the coding tree). Characterized data and quotes from the data were then further analyzed (see Section 4.1.6 for results).

3.3 Validity and reliability

The first research question endeavored to seek a comprehensive overall picture of the forms of socially just low carbon experiments in Finland. Despite this disposition and the extensive

amount of reviewed material, the mapping could provide only a snapshot in time. The majority of the materials were online-based and may not be permanently available, which decreases the reliability across time. The depth of the analysis and validity of the materials and methods was also limited by the analyzed data type, as the experiment descriptions and their accuracy were not controlled across the cases.

Regarding the second research question, the nature of the interviewees set some limitations to the study. Even reaching some desired interviewees proved to be challenging as the initial interview targets included many high officials in the city administration. This was especially the case in Helsinki. As the interview material is influenced by the selection of informants, this arrangement could have applied limitations to the validity of the content. In the end, interviews were undertaken with officials in each part of the city organization that was previously recognized as targets. Inquiries in interviews and with city contact persons led new departments to be recognized as possibly interesting, which contributed to the validity of this study's content.

Analyzing qualitative data by one individual was recognized as a limitation to the lack of interrater reliability of the study (Julien, 2008). To address this, triangulation was used in the data collection process to increase internal consistency and, through it, increase the reliability of the study. The use of an abductive manner in the content analysis allowed the measurement to cover more broadly all aspects of the phenomenon and increased the validity of the methods and findings. Also, the fact that the informants were the highest-level professionals in their field increased the validity of the study. Two or three interviews in each case municipality turned out to be sufficient as the subject matter is well-defined and narrow.

Concerning the second research question, the results of this study were limited only to the four case municipalities. Examining if the results could be generalized to apply to a larger group of Finnish municipalities was left for future research. In addition to this, only civil servants from municipalities were interviewed. The results are provided from this viewpoint, and questioning other experts, and cooperating with municipalities, could be potential future research questions.

4 Results

Section 4.1 provides an overview of the range of experiments included in the experiment mapping and responds to the first research question about the forms of experiments. Section 4.2 addresses the second question about the challenges municipalities face when engaging in experimental policy engagements.

4.1 Mapping socially just low carbon built environment experiments

This section begins by providing context to the results of experiment mapping (Section 4.1.1), showing the temporal and spatial position of the experiments. Section 4.1.2 looks at the experiment types and the change that the experiments generated. After that, diversity in the types of low carbon (Section 4.1.3) and social justice (Section 4.1.4) experiments were examined. The intersection between low carbon and social justice is explored in Section 4.1.5. Finally, Section 4.1.6 examines the case municipalities in the national mapping.

4.1.1 Background information and context

According to the experiment mapping, experiments were implemented to a great extent in municipalities with a larger population. Over half (54%) of the experiments took place in large municipalities (over 100 thousand residents), and only a few (8%) experiments took place in small municipalities (less than 5 000 residents). Over half (55%) of all the experiments took place in suburbs, about a fifth (19%) in urban city centers, and almost one out of ten (9%) in rural areas. The experiment location is described in further detail in Appendix D. Type of build and building where experiments took place can be seen in Figure 1.

The phenomenon, or at least its proliferation, is relatively recent as almost all (95 %) of the experiments took place between 2010 and 2022. The experiments in the mapping were limited in the temporal dimension. The duration of a single experiment was found to be relatively short. Over half (57%) of the experiments lasted for a maximum of one year, and a limited number of the cases (16%) took place in more than three years. Experiment timing is presented in more detail in Appendix F.

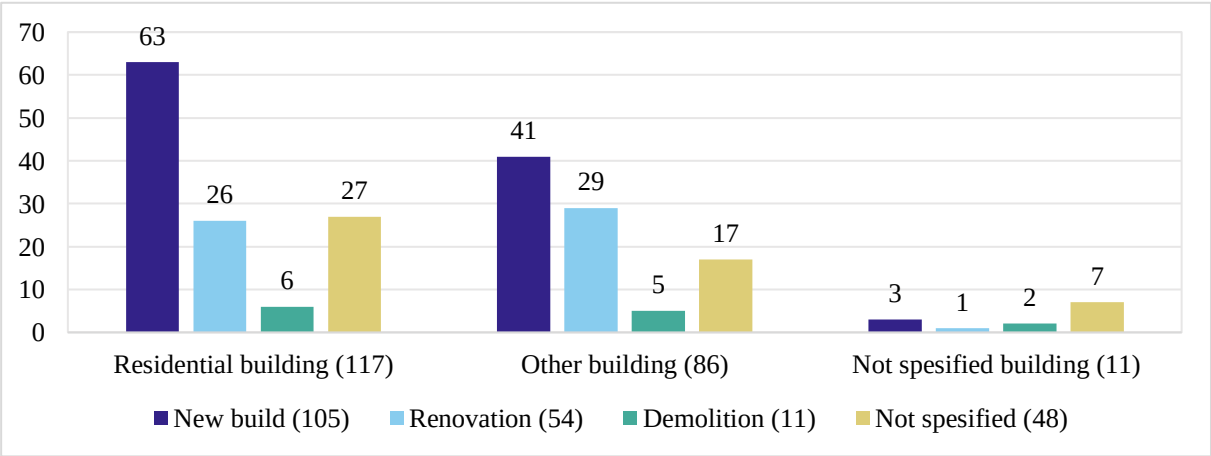

Figure 1. Type of building in the experiments (see Appendix F for more detailed description)

4.1.2 Experiment type and aims

Experiments were found in all four categories that were identified by Kivimaa et al. (2017). Most cases were identified as niche creation experiments (60%), with a smaller representation in categories of market creation (11%), spatial development (21%), and societal problem solving (9%). The experiments were further evaluated, focusing on the types of change that the experiments generated. Most of the experiments (84%) were identified to have multiple types of outputs or outcomes. From the 204 recognized experiments, 141 (69%) had learning-focused (changed discourse, policy and institutional change, and changed consumer or citizen practices) and 180 (88%) substantive focused outputs and outcomes (built environment and infrastructure change, new technology, new business practices, and new market or market change). Figure 2 presents the detailed allocation into the experiment categories. The categories for intended change that the experiments generate are presented in the order of frequency of appearance.

In niche creation experiments, the outputs were often precise and easily recognizable (Kivimaa et al., 2017). One example of this type of experiment was the energy renovation experiment implemented in an apartment building (Pohjolankatu 18–20) to make it carbon negative. This case included both learning-focused (changed discourse and new consumer/citizen practices) and substantive outputs and outcomes (built environment and infrastructure change, and new technology). This experiment generated an improved understanding of the costs and effects of the experimented energy efficiency renovations (changed discourse). New consumer practices were established as the housing association started to sell surplus heat to the district heating network. To achieve these changes in the experiment, many changes to the built environment were made, including the installation of photovoltaic panels and additional insulation, for example. Many new technologies, such as wastewater heat recovery and a two-way district heating network, were applied in the case.

In market creation experiments, for example, focusing on the digitalization of wood construction (cross laminated timber) included both learning-focused (changed discourse) and substantive outputs and outcomes (new market or market change, and new technology). The changed discourse was created by combining several production machines and design software to make the use of cross laminated timber more aesthetically pleasing, cheaper, and faster. The market change was created by enabling a new type of construction from cross laminated timber with the new technology to cut the wood that was created in the experiment.

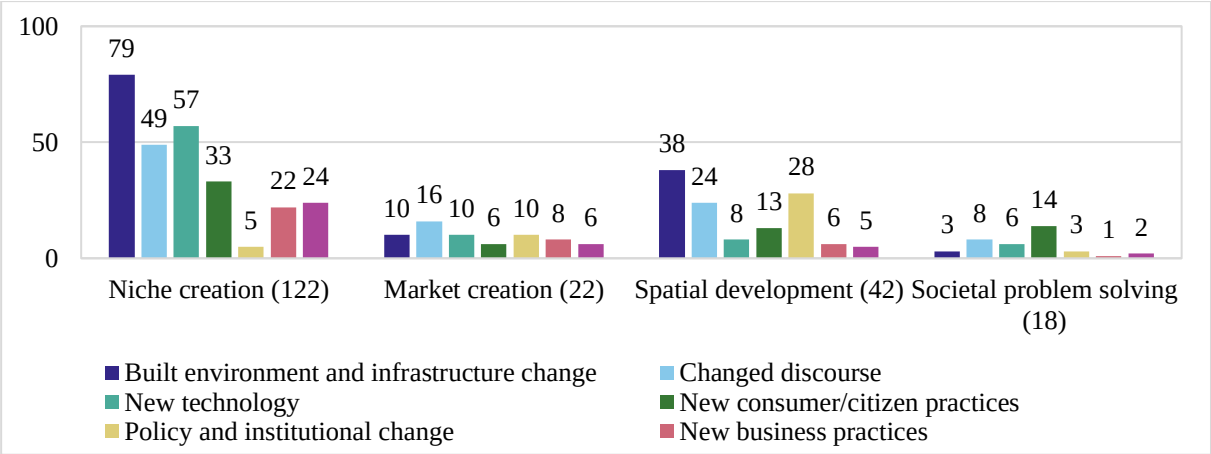

Figure 2. Experiment type and the change that the experiments generated

Roof-top extension (Rakuunantie 1) experiment with low-carbon material choice, which included evaluation for raising the buildings in the whole area, was an example of a spatial development experiment. This experiment included both learning-focused (changed discourse, and policy and institutional change) and substantive outputs and outcomes (built environment and infrastructure change, and new market or market change). The experiment created changed discourse as it introduced a sustainable way to finance renovations in an apartment building in the area, creating a new market for these extensions at the same time. In the experiment, deviation from the land use plan was made (policy and institutional change) to build the additional story (built environment and infrastructure change).

At the other end of the scale, in societal problem solving or change experiments, the division between outputs and outcomes was found to be more complicated than in other categories (Kivimaa et al., 2017). An example of this was the energy certificate law. The certificate was not required for the buildings with low resale or rental value. Only learning-focused outputs and outcomes (new consumer/citizen practices and policy and institutional change) were recognized in this case. The requirement of energy certificates created new citizen practices (such as reading energy certificates as a buyer and potentially acquiring one as a seller) for the people participating in the housing market. The policy change in the case was apparent as this case is a new law that itself is a policy instrument.

4.1.3 Low carbon experimentation

From the 204 experiments, 193 cases contained some type of low carbon solution. The eleven experiments (5%) that did not contain any low carbon solutions were experiments focusing solely on social justice. Some experiments had only operational (56%) or embodied (18%) energy solutions, and some contained both (21%). Table 9 presents the occurrence of the

embodied and operational energy categories and their subcategories and provides one example in each subtype. Most of the experiments (65%) had more than one type of low carbon solution. In embodied energy category, lowering the carbon footprint of building material production stood out as the dominant category of experimentation with 58 cases, from which 45 used wood as a building material. The second largest category in embodied energy cases was construction, followed by renovation and final demolition with an equal number of cases, on-site delivery, and maintenance. Concerning operational energy, the categories with the largest number of cases were the use of renewable energy and energy management, followed by building services, energy design, insulation, passive components, and energy behavior.

Table 9

Low carbon case experiments by subtypes and related examples

Type	Subtype	Example
Embodied energy (79)	Building material production (58)	Using surplus materials for the construction of a communal sauna (Sompasauna)
	On-site delivery (6)	Only transporting the ready-made multi-story house to the final location on an island (Neapo)
	Construction (13)	Reducing the use of plastic in a housing construction project (Metsäkissa)
	Maintenance (3)	Designing building services that could be renovated without demolition (Laakso hospital)
	Renovation (12)	Apartment building renovation with wooden elements (Innova house)
	Final demolition (12)	Identifying reusable parts and fixtures and finding a new use for them (circular construction event)
Operational energy (156)	Energy design (26)	Designing using heat from the computer room to warm the medical center and vice versa (Minerva & DNA)
	Passive components (20)	Achieving energy efficiency with the shape and orientation of the building and windows (Concept Olavilla)
	Insulation/air tightness (23)	Passive wooden apartment building with low air leakage rate (PuuMERA)
	Building services (47)	Heat recovery from exhaust air and wastewater (Pohjolankatu 18–20)
	Use of renewable energy (95)	Solar collectors were integrated into steel roof solution (Ruukki solar roof)
	Energy management (83)	Product for real-time monitoring the home electricity consumption (Fortum home display)

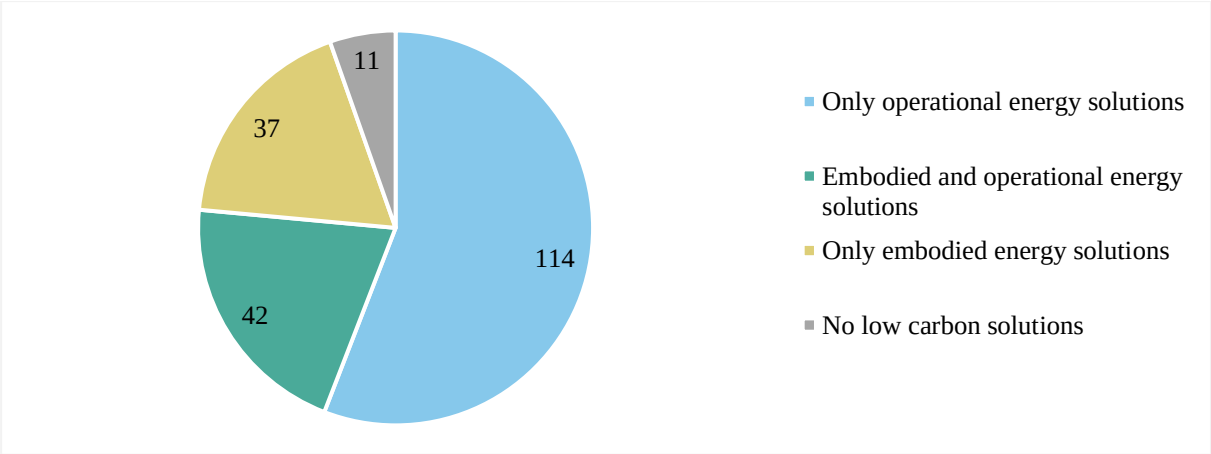

Figure 3. Types of low carbon solutions

4.1.4 Social justice experimentation

Social justice, in one form or another, was addressed in 191 (94%) of the 204 cases. The high number of cases where social justice was addressed is explained mainly by the nature of low carbon experimentation. Much experimentation with, for example, energy efficiency involves high penetration of efficient service (virtue) and the preservation of resources for future generations (posterity). Virtue was recognized in 76 (40%) and posterity in 153 (80%) cases. Because of the inherent nature of these two social justice categories in the low carbon experimentation, they are not examined further and are excluded in the subsequent analysis.

Even disregarding efficiency (virtue) and resource egalitarianism (posterity), 77 experiments (38%) engaged with multiple forms of justice. Other categories, accessibility and subsistence (23%), due process (20%), intergenerational equity (4%), subsidies (1%) and externalities (1%) were represented to a varying extent (Table 10). In terms of accessibility and subsistence cases, nearly half of the experiments (43%) targeted the most vulnerable members of society, including those in need of public housing, the elderly, students, and immigrants, for example. Other accessibility and subsistence (welfare and happiness) cases attempted to improve the quality of life, for example. In due process cases, most of the experiments (83%) included participating experiment target groups in the process somehow. In the third (33%) of these cases, the target group was able to participate in the experiment process from the beginning. These were all bottom-up experiments where the experiment arose from the actual target group. Over a third (38%) of those experiments enabled the participants to influence the content of the experiment at some level. The rest of those experiments (30%) included ways of participating, such as participating in the implementation of the experiment and participating as a user of the experiment.

Table 10

Social justice case experiments and examples

Topic	Example	
	Description	Link to social justice
Resource egalitarianism (posterity), 153	Identifying reusable parts and finding a new use for them (circular construction event)	Reducing resource consumption by recycling reusable parts from a demolition site
Efficiency (virtue), 76	Measurement and calculation of construction site emissions to verify the effects of the measures (emission-free construction site)	Reducing inefficiencies and developed emissions on construction site
Accessibility and subsistence, (welfare and happiness), 46	Zero energy building providing assisted living for older people in poor health (Mestariasunnot)	Targeting vulnerable members of society and providing access to low carbon solutions in their housing
Due process (procedural justice), 40	Co-construction project with communal energy (Husulanmäki)	The experiment rose bottom-up, with the residents being involved in it from the beginning
Intergenerational equity (fairness, responsibility, and capacity), 8	Developing transformation elasticity concept for wood construction (transformation elasticity)	Ways to adapt the building to the unknown needs of future generations and through this longer building lifetime
Subsidies (freedom), 2	An energy certificate is not required when the building is low in resale or rental value (energy certificate law)	Not forcing energy certificate (and the costs associated with it) on those living and renting the lowest price buildings
Externalities (utility), 2	Offering housing to homeless young people (communal housing experiment)	Reducing negative externality of housing (homelessness in this case)
Human rights and social conflict (human rights), 0	Human rights were not addressed in any of the experiments	-

4.1.5 Social justice in low carbon experimentation

This section provides a more comprehensive picture the how the experiments engage with low carbon and social justice aspects together. One requirement for identifying the experiments was that low carbon and/or social justice experimentation was applied in the context of built environment. Figure 4 presents the prevailing criteria for identifying the cases.

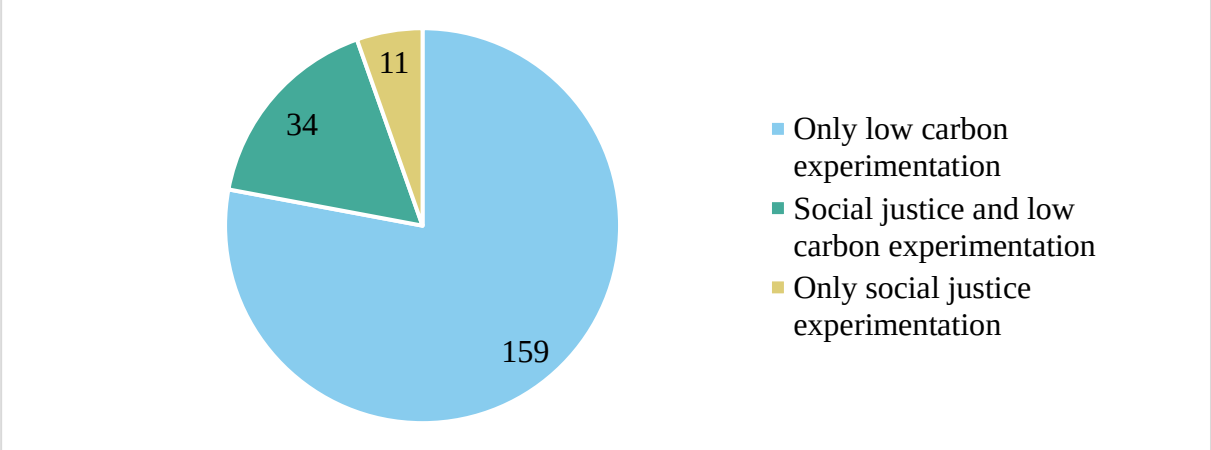

Figure 4. Types of experimentation in the cases

In Figure 4, the experiments were divided into four categories based on the low carbon type, and social justice types were examined in these categories. As can be seen in Figure 5, the themes of accessibility and subsistence (welfare and happiness) and due process (procedural justice) are present in a more significant portion of cases in operational than embodied energy cases. Concrete examples of the experiments integrating both low carbon and social justice aspects are provided in Table 11.

Table 11

Examples of experiments combining low carbon and social justice goals with examples in parentheses

Type of social justice	Type of low carbon		
	Only embodied energy	Embodied and operational energy	Only operational energy
Accessibility and subsistence (welfare and happiness)	Easily transferrable wood construction building designed to meet the needs of temporary accommodation in an urban environment. The experiment targeted vulnerable members of society (such as refugees and homeless students starting school), providing them access to housing and low carbon solutions. (Kokoon)	Extensive roof gardens and biodiversity roofs to achieve impacts on rainwater, energy efficiency, and the resident community. Increased air quality and amenity value biodiversity roofs and the community building aspects of the shared kitchen gardens contributed to increased welfare of the residents. (Greenest of the greens)	Zero energy building providing assisted living for elderly people in poor health. The experiment targeted vulnerable members of society (elderly) and provided access to low carbon solutions in their housing. (Mestariasunnot)
Due process (procedural justice)	The village association chose to build a communal building from straw bales to bind carbon. The experiment rose bottom-up with the villagers being involved in it from choosing it. (Straw bale house)	The housing association initiated a low carbon rooftop-extension to finance other renovations. The residents of the building were involved in the experiment from choosing it. (Rakuunantie 1)	Product for real-time monitoring of the home electricity consumption, which allows consumers to make informed choices and decisions on participation in energy-saving actions. (Fortum home display)
Intergenerational equity (fairness, responsibility, and capacity)	Developing transformation elasticity concept for wood construction. The goal of transformation elasticity is to make the building more adaptable for future generations and prolong its lifetime. (Transformation elasticity)	Co-construction of sustainable communal housing where renewable community energy solutions for the area will be carried out. Attempting to protect future generations from energy-related harms. (Husulanmäki)	Testing solar community IT service to share the benefits of solar energy in a housing company. The experiment was driven by a solid motivation to reduce the impacts of the residence. (Haapalahdenkatu 11)
Subsidies (freedom)	-	-	The housing company received EU financing to carry out an energy renovation. The renovations resulted in financial savings for the residents. (Pohjolankatu 18–20)

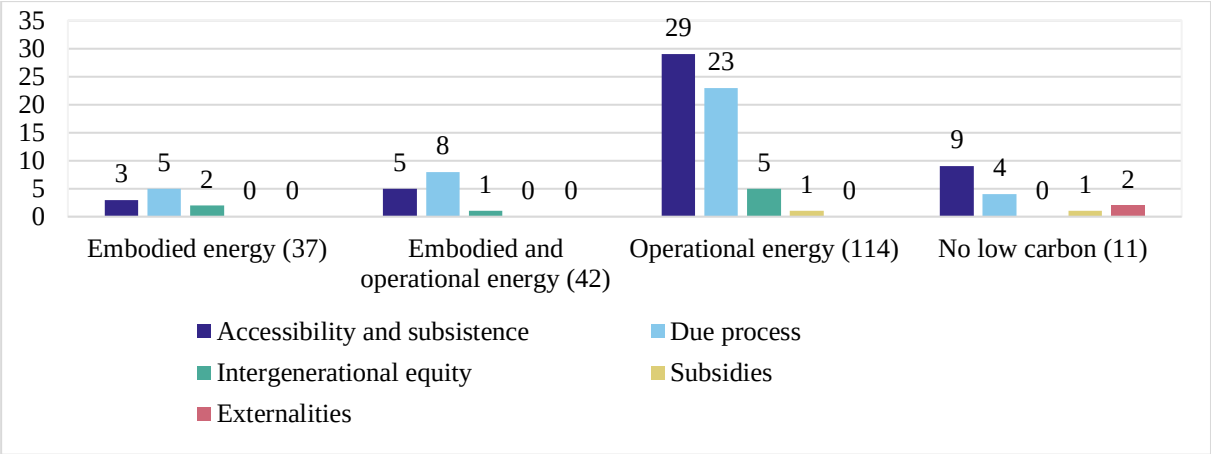

Figure 5. Breakdown with types of social justice in low carbon experiments

4.1.6 Case study municipalities in a national context

This section provides context to the results of the interviews by looking at the case municipalities within the national experiment data. The purpose is to provide background information about the experiments happening in the case municipalities before diving further into the municipality engagements and challenges in Section 4.2.

Experiment stakeholders were reviewed in the national mapping (see Appendix E). Municipalities functioned as a financier in almost a third (30%) of the experiments. They acted as a financier in more experiments than any other stakeholder group. Municipalities were a participant in over half (52%) of the experiments. Only private businesses took part in a larger number (67%) of the experiments. Though private businesses took part in more experiments than municipalities, the municipalities initiated and/or owned a larger number (29%) of experiments than private businesses (24%).

The case municipalities (Helsinki, Joensuu, Turku, Vantaa) and their representation in the national mapping data were reviewed (see Appendix D). About a fifth (21%) of the whole Finnish population lived in the case municipalities at the end of the year 2021 (Official Statistics of Finland, 2022). All of the case municipalities were represented in the national mapping data, with in total, 74 (36%) of the recognized experiments taking place in one of them. 48 experiments took place in Helsinki, 5 in Joensuu, 11 in Turku, and 14 in Vantaa. At a national level, Helsinki was the municipality with the most significant number of cases.

4.2 Municipality engagements and recognized challenges in experimental policy engagements

This section begins by providing context to the results of the interviews (Section 4.2.1). Section 4.2.2 looks at the municipality engagement and challenges in building and nurturing niches, Section 4.2.3 in expanding and mainstreaming niches, and Section 4.2.4 in opening up and locking regimes.

4.2.1 Background information and context

This section provides an overview of the municipality engagements and recognized challenges. The purpose is to provide background information about the municipality engagements and give context to the results of the second research question. In light of the interview and additional document data, municipalities were mainly focusing on building and nurturing niches (81%). Expanding and mainstreaming efforts (15%) were a lot fewer, and close to zero engagements dealt with opening up and unlocking regimes (3%). The division into these macro-processes is presented in more detail in Table 12.

Only one-tenth (11%) of engagements and challenges raised in the interviews and identified in the supporting documents focused explicitly on the GHG mitigation and/or built environment. The rest (89%) of the identified engagements and challenges were related to the experimentation process. Around a quarter (26%) of the engagements and challenges were related to the social justice aspects. The appearance of social justice in the recognized engagements and challenges is presented in Figure 6. Engagements and challenges with social justice aspects in them are presented further in upcoming sections under the transformative outcomes they relate to.

Table 12

Municipality engagements and perceived challenges in experimental policy engagements

Macro-process	TOs	Engagements	Challenges
1. Building and nurturing niches (208)	1.1 Shielding	24	19
	1.2 Learning	19	6
	1.3 Networking	62	35
	1.4 Navigating expectations	31	13
2. Expanding and main-streaming niches (39)	2.1 Upscaling	9	7
	2.2 Replicating	6	1
	2.3 Circulating	4	1
	2.4 Institutionalizing	8	4
3. Opening up and unlocking regimes (8)	3.1 De-aligning and destabilizing	1	2
	3.2 Unlearning and deep learning in regimes	0	1
	3.3 Strengthening regime–niche interactions	2	0
	3.4 Changing perceptions of landscape pressures	1	1
Total	255	166	90

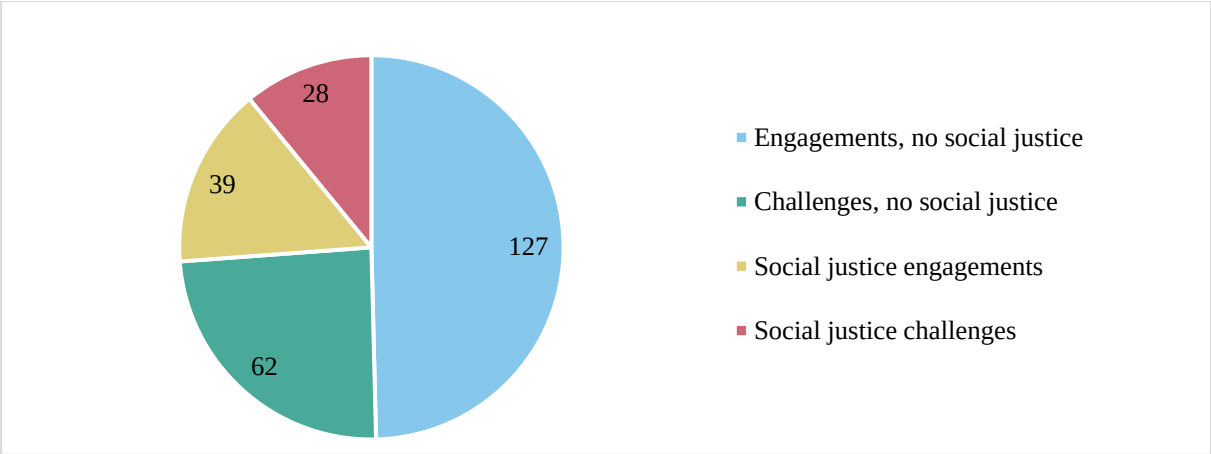

Figure 6. Social justice in municipality EPEs and challenges

4.2.2 Building and nurturing niches

This section answers the questions of what kind of municipality engagements built and nurtured niches and what kind of challenges municipality representatives identified when engaging in building and nurturing niches (see Appendix K for the full list and Table 13 for specific actions).

Table 13

Municipality models and actors to build and nurture niches

Transformative outcome	Case municipality engagements			
	Helsinki	Joensuu	Turku	Vantaa
Shielding	Experimental culture, innovation agents, an innovation company, innovation fund, living labs, testbed	Climate partnership, development manager	Experimental culture, project development department, testbed	Experimental culture, project office, a specific testing ground for experiments, testbed
Learning	Agile piloting model, data collection, innovation agents, innovation company, reporting, living labs, testbed, urban environment innovation team	Development manager, reporting	Agile piloting model, information service department, project development department, reporting, testbed	Agile piloting model, data collection, project office, reporting, a specific testing ground for experiments, testbed
Networking	Agile piloting model, innovation agents, an innovation company, living labs, multi-municipality projects, testbed	Climate partnership, FISU network, multi-municipality projects	FISU network, participation coordinator, testbed, voice your opinion platform	Agile piloting model, multi-municipality projects, project office, testbed
Navigating expectations	Agile piloting model, networking	Development manager	Agile piloting model, experiment service tool	Agile piloting model, networking

4.2.2.1 Shielding

Case municipalities had several engagements that offered shielding for experiments. The municipalities contributed to the provision of protected spaces for experiments by offering funding, spaces for trial and error, and access to data for the experiments. Helsinki, for example, provided funding to experiments through their innovation company Forum Virium Helsinki which had developed a purchasing model to fund agile piloting. Helsinki offered spaces for trial and error in living labs such as Kalasatama and Vantaa in the area of Aviapolis by, for example, allowing testing of robot buses in the area. Turku, for example, had worked on opening and making city data, such as transport data, easier to use to give experiments possibilities for using it. Municipality representatives also saw that the municipalities provided space for experimenting with national policies.

Municipalities obtained external resources to shield experiments. For example, the EU and different ministries provided funding, and national actors like Motiva provided expertise for municipalities to shield experiments. These funding instruments, together with city strategy, guided what kind of experiments were pursued. Funding instruments, like EU funding, were seen to require taking social justice into account in the experiments. The separate funding instruments were also seen as a prerequisite for engaging with many of the experiments. All case municipality strategies mentioned engaging with experiments in some way. Joensuu, for example, had a specific goal for the city to experiment with participative budgeting in its strategy. The municipal strategies of Helsinki, Turku, and Vantaa discussed about broader experimental culture and supporting experiments in addition to mentioning specific experimental fronts. The external resources also guided the municipal employees to work driven by the experiment outcome. They often strived to engage with experiments that they perceived to have possibilities for continuity. For them, this often meant that there should be another experiment and another funding to follow after the one ended.

All of the case municipalities had special posts, offices, and/or companies for shielding and hosting experiments. Helsinki, Turku, and Vantaa all had Testbeds that collected together the development and testing opportunities for new products and services that the municipalities offered. These three municipalities also had special project offices that offered, for example, help with funding applications for other municipality departments. Helsinki also had a specific innovation fund for funding experiments and projects and the innovation company Forum Virium Helsinki for facilitating and acquiring experiments. Joensuu, in turn, had a development manager managing the bigger picture of experiments and projects. The goal of these posts and

units was to provide shielding more efficiently with a centralized model and provide synergy benefits. Managing several experiments was seen as laborious, but these offices were seen to make it easier. One of the main tasks for these posts and offices was to get the experiments going. This meant that experiment owners took care of the experiments after that. One informant (T3) explained that someone had to monitor that the experiments were "going in the right direction", which required "an owner who has time to monitor and support the resources".

Interviewed municipality representatives also recognized challenges in shielding experiments. One recognized challenge was seen to be the lack of funding and time or people to do the shielding and the administrative burden related to the experiments. For example, one informant (T1) saw that the job related to the shielding and administrative burden was often added on top of a full work schedule, and "some people end up with 150 percent work". Turku sought to address this issue by planning to develop a model to combine crowdfunding with other funding instruments to finance experiments (T10). The municipality process was also recognized to be challenging and hard to understand. "Sometimes we do not know what we can do", one informant (H6) stated. Municipality process and external funding instruments were recognized not to be the most suitable for very agile piloting or, for example, changing plans if something did not work. "The specs that have to be done during the project have been defined beforehand, and they have to be done" stated one of the informants (H2) when describing the limits the funding created. This meant that even if better solutions were found during the experimentation process, the experiment actors had to follow through with the original plan. It was also recognized that experiments should be able to fail, but municipality rules did not always allow that kind of space to exist as no special rules or exceptions could be applied for experiments. The practice of chaining experiments and multiple funding instruments after one another also required the last experiment not to fail so that the next could start.

Some challenges were also specific to the subject matter. For example, the time-limited funding instruments seldom suited well together with long-term construction projects. "Discrepancy of schedules" was described by one of the informants (T1) even more in the low carbon construction as the municipality process was seen to be "quite slow, and especially the impact perspective". Low carbon solutions were also recognized to be hard to compare, monitor, and support with the limited resources and subject matter expertise municipalities have. One informant (V1) described how they were not "experts in that (low carbon) area" and also did not "have time left for investigating and monitoring".

4.2.2.2 Learning

Case municipalities had several engagements focusing on learning from the experiments. These engagements included providing and developing practices and support structures to promote learning, helping experiments to survive challenges, and transferring learnings to be utilized outside the project team. The tools and structures to support learning were related to assessing, evaluating, and reporting experiments and experiment learnings. One respondent (H1) saw that "the clearer the process" was, the more space it gave to "the people responsible for content to concentrate on the content itself". Many of the tools and structures were affiliated with the funding instruments. The structure of funding instruments made the experiments to be "tracked and reported very actively" (V3).

The municipality representatives aimed at sharing the learnings and taking them into practice. The learnings were attempted to share further by networking, providing data for open access, and communicating the learnings outside the project team. The municipalities engaged in, for example, "information exchange meetings" (H2) to transfer learnings outside the project team. One informant (J1) described having "tried to distribute the learnings by communicating them to other municipalities after the project".

Learning was seen as one main goal and a crucial part of the experiment process. One informant (T3) described learning to be "an ongoing process of how to move things forward". To support learning, municipalities also had dedicated personnel that worked on reducing the sense of "risk associated with new operations" (H7). This was done by identifying "relevant officials, contractual and procurement procedures, as well as data security elements" and forming "networks with businesses and other partners" (H7). Learning outcomes focused mainly on what actors were doing rather than questioning frames and assumptions of structures and activities. For example, in one experiment, "the goal was to understand what each actor's responsibility" was in climate change mitigation, one respondent (H2) explained.

Municipality representatives also recognized challenges in learning from the experiment process. These included, for example, the difficulty in using gathered lessons, some knowledge (especially those related to the subject matter) remaining silent due to changing project personnel, and lack of adequate reporting from failed experiments. "However interesting the topic is, there may not be resources" to report failed experiments, one municipality representative (T1) explained. The nature of experimenting and the possibility of failing might have been forgotten when evaluating the experiments. For example, one respondent (J1) explained that the experiments should "produce a permanent result or a model which would

also be utilized later on". The structures that municipalities had for supporting learning were not always known by people who were doing the actual experiments. This resulted in conflicting views inside single municipalities on whether there were practices or structures to support learning or not. One respondent (T1), for example, was wondering if the learnings were "explicit and identified" and "possibly reported somewhere" or did the learnings only stay as "silent knowledge".

4.2.2.3 Networking

Case municipalities had several engagements focusing on networking. To enable experimentation, different municipality departments within the municipality engaged in networking with each other and other actors. One respondent (T3) described actors to engage in networking within the municipality organization, including, for example, the project development department for "funding and/or resources", "customer service management" for the "digital side", and "people in different service areas, such as healthcare, education" and "the urban environment" to act as experiment owners and actors. These municipality actors operated as intermediaries (see Section 2.2.2), coordinating, supporting, and developing networking. The other actors included international and national level actors (i.e., EC, different Finnish ministries, the Finnish Environment Institute, and Motiva), other municipalities (also from abroad), companies, organizations, and residents affiliated with experimentation. One informant (V3) described these actors and networks to include, for example, the Ministry of Economic Affairs and Employment of Finland, "6Aika", which is "a collaboration of six cities" (Helsinki, Espoo, Vantaa, Tampere, Turku, and Oulu), the municipalities in "the Helsinki metropolitan area", "businesses", "housing companies" and "residents". Networking between different actors included, for example, "workshops and network meetings", one informant (H1) described.

Experimentation was seen to create a neutral and safe space that made exchanging ideas easier and created potential for new networks. Active local partners were seen to help experiments succeed. Municipalities aimed to utilize the "resources and know-how" (H1) the network had. Municipality representatives saw committing actors to the process, transparency, and keeping different actors aware of the process to be important. Participating the residents in the process was seen to help the experiment to make a lasting and large-scale impact. It was also seen as an essential part of a just transition. Municipalities had goals and programs to participate in and empower residents. One informant (V2) described the ways the residents were networked to include, for example, "a new participative experiment" where there was "a jury

of residents" with whom the municipality representatives tried "to develop the resource wisdom roadmap". Special councils were formed to help to participate in those in the most vulnerable positions in society. One municipality representative (T1) described that they had, for example, "disability council", "senior citizen council", children's council", "youth council", "area-specific work for areas with lots of immigrants", and "participation network". Municipalities also engaged in behavioral change experiments with residents. One respondent (J1) described, for example, an experiment where they "invited households to try out low-carbon and material-efficient living".

Municipality representatives also recognized challenges in networking. The biggest one was seen to be having the right actors at the table to help the experiment succeed. One municipality representative (V3) described that they had challenges in reaching new kinds of actors because, for example, where they communicated "the opportunities to start doing an experiment with the city". One respondent (J1) described that they had work to do "to make climate work accessible" and "give everyone the opportunity to participate". Things like schedules, problems in communication, procurement act rules, lack of resources, interest or perceived importance, and key personnel changes were seen to create challenges in bringing the relevant actors together. Experiments also faced resistance "in the form of absence", for example, described one informant (V3). Differing aims between the participants were seen to make networking challenging.

Networking with residents in the early phases of experimenting was seen to be challenging, and residents often participated in the experiments at the very end phases. One respondent (J1) described that the residents were often offered "a pretty finished package", and some ways of participating were "in a very small scale", like inviting residents to participate in "planting the neighborhood carbon sink park". Another respondent (T1) described that "planning an experiment" often started "so quickly, that at the stage there" was "no participation", and it happened only "at later stages". No uniform indicators or clear processes for accessing participation in experiments were recognized.

Some challenges were also specific to the subject matter. With construction projects, it was seen hard to get the residents to participate as the actual future residents were often not known in advance. One respondent (V1) described that the neighborhood had participated only when they had "some concerns about the plans" like, for example, "if there will be rehabilitative housing or something like this". Municipality representatives also recognized challenges in implementing social justice in some of the experiments. One informant (V1) described a case

where seven apartment buildings, where it had “probably been some disturbances for the neighbors”, were demolished, the “city’s rented apartments” were “moved to other areas”, and the municipality required “the constructor to build owned apartments” in the more environmentally friendly housing that was built in the place. Demolishing buildings and, for example, moving the municipality-owned rental housing elsewhere were seen as ways to address segregation and poor socioeconomic status in a specific area. These kinds of cases possibly increased the cost of living in the area and made the former residents involuntary move elsewhere. It was recognized that these cases affected most of those residents that were probably already in vulnerable positions in society and probably excluded them from participating and networking in decisions that concerned their own housing situation.

4.2.2.4 Navigating expectations

Case municipalities had several engagements focusing on navigating expectations. Avoiding empty promises and making the uncertain nature of experimenting clear were seen to be important. One informant (V2) explained that there had to be a “joint understanding” that it was an experiment and the “project can also fail”. Experiment participants were seen to have different expectations, interests, and motivations for participating. One municipality representative (V3) saw that to help experiments succeed municipalities had to “act neutrally”, “transparent”, and prepare everyone to be “ready to compromise”. Another respondent (H1) described that being “open-minded enough” was crucial to “actually find something innovative that you did not even think you could ask”. Municipality expectations for experimentation included, for example, staying inclusive, doing something novel, finding the best possible solutions, and having an impact on municipality strategy goals (i.e., carbon neutrality, resource wisdom, or participation). One informant (T1) saw that the municipalities should not expect a single experiment to “solve a problem in its entirety” but rather to make progress “in the right direction”. These goals and the municipality’s ideals on what kind of experimentation was to occur, directed how expectations of others had to be molded.

Municipality representatives also recognized challenges in navigating expectations. Navigating expectations was seen as challenging, with every individual having different expectations, interests, and motivations to participate. One informant (H6) described that challenges occur because one could not “see the whole process” in the beginning. Another informant (H5) saw that even if there was “a clear vision” of the aims, it was important to stay open-minded to find the solutions and address the challenges no one anticipated there to be.

All parties expected the experiments to have impact and scalability, which was in contradiction with the nature of experimentation and the experiment's ability to fail. This led municipalities to experiment with some solutions that were not novel. One respondent (T1) saw that it was difficult "to do something that" was "one hundred percent new," and some things that were marketed "as an experiment" had "been done for a long time" already. The municipality process regarding experiments was seen to be slow-paced. One respondent (H2) described that in one project, they had "planned a lot of things" that had not "moved forward that much", but they believed things to "start up in a couple of years" as these things often took "some time".

Some challenges were also specific to the subject matter. Carbon emission reductions were seen to be challenging to quantify and monitor. This was especially seen to be the case in short-term experiments, as the actual impacts were seen only long after the project had finished. One municipality representative (H2) explained that for this reason, they tried to get projects that were "long-term enough" to "already see their impact" during the project. Municipalities sometimes tried to use some environmental certificates to ease the evaluation and move the responsibility of monitoring to someone else. One municipality representative (V1) described the reason for this to be that they did not always have resources for the "monitoring and resources and know-how" that following up with the experiments required. In the built environment sustainability experiments low carbon aspect was almost always the starting point, and possible social justice aspects were described as an afterthought. In these projects, the municipality officials were mainly environmental experts. They sometimes had a hard time seeing the connection between low carbon and social justice.

4.2.3 Expanding and mainstreaming niches

This section answers the questions of what kind of municipality engagements expanded and mainstreamed niches and what kind of challenges municipality representatives recognized when engaging in expanding and mainstreaming niches (see Appendix L for the full list).

4.2.3.1 Upscaling

Case municipalities engaged in upscaling. These contributions included planning, guidance, examples, incentives, and models to upscale experiments, for example. Upscaling was seen to include several decisions, including whether to upscale and, if so, how to fund and organize the upscaling. Project offices were important intermediaries in this work as they were able to see comparable and quantifiable results and recognize whether they were worth upscaling. One informant (H1) described "a two-phased agile piloting model" to be one tool for upscaling small

experiments. In the first phase, solutions were experimented with quickly and on a small scale. Most promising phase one trials were chosen to continue to the larger phase two implementation. The phase one implementation, results, and learned lessons were considered when choosing which experiments continued to phase two. Municipality representatives also saw that upscaling could not only happen from the top down. One municipality representative (V3) described that there was "clearly a cultural change in action or already occurred", which did not support only having "top-down management" in the experiments as information was needed "from all sides".

Municipality representatives also recognized challenges in upscaling. It was seen that challenges in communicating the results inhibited upscaling the experiments. One respondent (V3) described that there was "so much information available" everywhere that it was hard to get the "good messages through" to upscale experiments. The availability of resources was seen to be another limiting factor in upscaling. One municipality representative (H2) explained that even when they had recognized that an experiment called Taloyhtiöklubi "proceeded well" and was "effective", they still did not have "enough resources" to upscale the experiment. Upscaling experiments by fitting them into everyday city work was sometimes seen as challenging. One municipality representative (V3) described that after the experiments, businesses sometimes had "wishes" that were beyond the scope of the municipality's role because their role could not be to "improve an individual company's profit margin, for example". It was also seen that when an experiment was very dependent on a single project worker, upscaling it was more challenging. One respondent (H2) explained this to be the case as the upscaling could not "depend on only one person or one actor" because municipalities had to "develop many different procedures" to upscale the experiments. It was also recognized that when experiments were upscaled, the social justice aspects became more critical. If it was recognized that social justice was not addressed adequately in the original experiment, it was seen that the challenges with social justice needed to be solved at the same time as other challenges that there were in upscaling an experiment.

4.2.3.2 Replicating

Case municipalities engaged in replicating the experiments. Municipalities had plans to replicate successful experiments in other contexts. One municipality representative (T2) explained that it was already described in the "project plan" which experiments would "be replicated and where". Municipality representatives also tried to communicate the results to give other areas and municipalities possibilities to replicate the experiments. One respondent

(J1) described that they had ”tried to distribute the learnings by communicating them to other municipalities after the project” so that the same kind of experiments could “happen in other places as well”. Municipalities also supported spaces for experiment actors to share their results to help someone else replicate the experiments. One respondent (H2) described an example of this to take place in “Taloyhtiöklubi”, where the representatives of different housing associations shared their “good experiences, such as geothermal heating”, with other housing association representatives to “get excited about them in turn”.

Municipality representatives also recognized that replicating experiments required learning and translation between different contexts and neighborhoods. One municipality representative (H3) described that when replicating experiments in other contexts, “the differences in neighborhoods” showed that the experiments could not be just “duplicated in the whole city” but “specific area’s needs” needed to be taken into account. To curb these challenges and translate experiments better into other contexts, it was seen to be important to get active local partners (i.e., residents, property managers, and businesses) to join in the replication.

4.2.3.3 Circulating

Case municipalities engaged in circulating ideas, resources, and knowledge between experiments. One respondent (H1) explained that “there might be shared ideas for two different types of experiments”, and as a result, they did “same things with different experiments”. Another respondent (J1) described an example of possible circulating where they were experimenting with calculating “road and infrastructure construction’s greenhouse emissions during the construction phase”, which could “be applied to larger building projects” in the future. One municipality representative (V3) explained how they circulated know-how and people between projects by moving the person “specialized in a particular theme” from “one project to another”. Units and people coordinating experimentation and projects were often responsible for these circulation engagements.

Municipality representatives recognized that circulating did not fit everywhere so well. In their legally mandated operations, municipalities had to keep in mind the regulations. One respondent (V3) explained that, for example, in “an experiment regarding health care and social services”, they could not “apply the same principles there as” in something else. In these kinds of cases, careful consideration and translation were required when engaging in circulating.

4.2.3.4 Institutionalizing

Case municipalities engaged in institutionalizing. One respondent (J1) explained how they had attempted to make things permanent. They had "gained a lot of good insights" from the "remote working experiments" that were now utilized in updating the "remote working guidelines" of the city (J1). One municipality representative (H2) described how they attempted to institutionalize niche rules by providing information about applicable measures. They explained that they had started to produce a "map service" where one could "click on a building on the map and immediately see what kind of measures" would be "worthwhile" when planning a renovation (H2). Another example of institutionalizing niche rules was bringing "climate actions in the city's annual budgeting plan" (J1). Municipality representatives saw that engaging in institutionalizing was, to some extent, project units' responsibility. Having longer-term projects was seen to be beneficial for institutionalizing purposes. Seeing the experiment's impacts during the project was seen to help with justifying institutionalization. Municipality strategies and climate programs mentioned goals to institutionalize experimental processes like, for example, participatory budgeting and the use of citizen panels.

Municipality representatives also recognized challenges in institutionalizing. One recognized challenge was seen to be the need to plan institutionalizing from the beginning of the project. This was seen to be challenging as, at the beginning of the experiment, it was impossible to know whether the experiment resulted in something worth institutionalizing. Another challenge was identified to be the lack of resources. Institutionalizing was seen to require resources, and municipalities had not always prioritized institutionalization in resource allocation. One municipality representative (V2) described that if there was something to be institutionalized into the normal city conduct after the experiment ended, the work had "to be included in some public servant's job description". The actual institutionalization was seen to take time in the slow municipality process. One respondent (T2) explained that after an experiment ended, it possibly took even a "few years" before anything was institutionalized.

To know what to institutionalize, municipalities were seen to need strong subject matter knowledge. One respondent (V1) explained that they could "make whatever demands" they wanted to in construction projects, but the question was what they should demand. Municipality representatives were, in some cases, seen to lack subject matter knowledge about socially just low carbon buildings and housing. This lack of know-how made evaluating and institutionalizing niche rules challenging.

4.2.4 Opening up and unlocking regimes

This section answers the questions of what kind of municipality engagements opened up and unlocked regimes and what kind of challenges municipality representatives identified when engaging in opening up and unlocking regimes (see Appendix M for the full list).

4.2.4.1 De-aligning and destabilizing

Case municipality representatives saw that national-level measures and policies were important in unlocking path dependencies to de-align and destabilize regimes. De-aligning and destabilizing measures were seen to be out of the municipalities' scope, especially in the building sector. One municipality representative (V1) recognized that "the regulations" had "to come from somewhere even higher up than what" they required. The municipalities' own engagements were limited to addressing faced resistance to more minor questions. "Communication and co-operation", as one informant (J1) formatted it, were the means municipalities used "right from the beginning, to increase the understanding" in hopes of curbing the resistance to change. The faced resistance was also recognized to inhibit the possibilities for de-aligning and destabilizing in regimes. One respondent (V2) recognized that there might have been resistance "against the overall sensibleness" of conducting experiments in the regime as established companies were possibly concerned for their profits and questioned "what benefit" de-aligning and destabilizing measures could have for them.

4.2.4.2 Unlearning and deep learning in regimes

Municipality representatives did not recognize municipality engagements focusing on unlearning and deep learning in regimes. Unlearning and deep learning in regimes was seen to be mainly out of the municipalities' scope in the same way that de-aligning and destabilizing were seen to go beyond the municipalities' leverage. Also, resistance to change was recognized as a challenge in the same way as in de-aligning and destabilizing. For example, one informant (J1) recognized that people were "unwilling to start changing their ways of working and trying something new" and resisted changes.

4.2.4.3 Strengthening regime-niche interactions

Municipalities engaged in strengthening regime-niche interactions, which was done by sharing data from niche experiments with the regime-level actors as well as supporting the sharing of new practices. One municipality representative (V2) described strengthening regime-niche interactions example included getting "data from the housing companies to one place" for the

whole regime to utilize. Strengthening regime-niche interactions were seen to be partly out of the municipalities' scope.

4.2.4.4 Changing perceptions of landscape pressures

Municipalities engaged in adopting new expectations that focused on changing perceptions of landscape pressures. This was done by setting goals and strategies that aimed to take climate perspective into account in decision-making and competitive tendering. Municipality representatives saw this to be challenging as they did not have the subject matter knowledge to properly re-assess to change perceptions of landscape pressures. One respondent (V1) described that there was a need to change the current status of subject matter knowledge, but it required them to find time from their "small resources" to stay updated and learn about the subject matter. Municipality representatives saw that changing perceptions of landscape pressures were mainly beyond the municipalities' leverage.

5 Discussion

This section discusses the results in light of the existing literature. Section 5.1 discusses the first and Section 5.2 the second research question, and Section 5.3 future research needs.

5.1 Forms of socially just low carbon experiments in the built environment

As the first task, this thesis systematically mapped 1 386 objects in 15 databases and further reviewed the recognized 204 unique built environment low carbon and/or social justice experiments to find what forms of experiments for socially just low carbon buildings and housing can be found in Finland.

According to the results, there is a limited focus on renovations in low carbon experimentation in the built environment. Most (51%) of the experiments took place in the construction of new buildings and only about a quarter (26%) in renovations of existing buildings. New buildings already use substantially less energy than old buildings because of tight construction standards (Saari et al., 2012). However, old, low-performance buildings form most of the Finnish building stock (Hirvonen et al., 2019). This, combined with the fact that building stock renews at an annual rate of 1–2%, means that emissions from existing buildings must also be reduced quickly (Sankelo & Alhola, 2020). This makes a broader focus on experimentation in the existing building stock necessary to reach Finland's ambitious climate neutrality goals.

Building from the conceptual lens on the range of experiments, niche creation experiments and built environment and infrastructure change stood out in terms of experiment

types and aims. The division of experiment types mainly followed the findings of Kivimaa et al. (2017) on climate governance experiments, with niche creation (60%) being the most prominent and societal problem solving (9%) being the smallest category in the mapping. The mapping data deviated from the findings of Kivimaa et al. (2017) in the higher representation of spatial development (21%) than market creation (11%) cases. Similarly, related to the type of the experiments, most (64%) of them resulted in the built environment and infrastructure change. The mapping outcome differs from the findings of Kivimaa et al. (2017) in the relatively higher representation of the built environment and infrastructure change, and new consumer/citizen practice cases. The relatively high number of spatial development experiments and built environment and infrastructure change might be connected to the fact that only built environment cases were reviewed in this study, while Kivimaa et al. (2017) reviewed several types of climate change mitigation experiments. On the other hand, the relatively higher number of consumer/citizen practice experiments found in this study might be connected to the type of reviewed data. Kivimaa et al. (2017) reviewed experiments based on transition literature, while the data of this thesis consisted of other experiment databases. In the reviewed databases, some of the experiments were reported by the citizens themselves, which might explain the fact that new consumer/citizen practices stood out in the results.

The results of this thesis indicated that operational energy was addressed more frequently than embodied energy. The cases in the mapping were seen to focus on the operational energy that contributed the most to the energy use of a building during its lifetime (e.g., Dixit et al., 2012). Embodied energy was mainly addressed in building material production, and the current focus on the promotion of wood as a building material (e.g., Finnish Government, 2019) was present in terms of a large number of wood construction cases. Concerning operational energy, the largest categories of experimentation were the use of renewable energy and energy management, followed by building services, energy design, insulation, and passive components. This was in contradiction to the preferential order of operational energy interventions suggested by Kalaiselvam and Parameshwaran (2014): energy design, passive components, insulation/air tightness, building services, and only then through the use of renewable energy, and energy management. One reason why this could be the case was that some of the more prioritized ways to address operational energy were not labeled as experiments. For example, energy design is something that is required from buildings in the construction standards (see Saari et al., 2012). This might have contributed to the fact that, for example, the use of energy design was reported only in a few experiments.

Only a few experiments sought to lower the carbon emissions and operational use of a building by addressing household energy behavior. This might be challenging as the technological solutions alone have not challenged how the impact of housing forms (e.g., Reid & Houston, 2013). Changing people's behavior and energy use through behavior has been found to be complicated (see Abrahamse et al., 2005). Possibly for this reason, low carbon homes have been seen as a viable solution for reducing the environmental effects of housing (e.g., Seyfang, 2010). Despite the promising prospects of low carbon technologies, even zero carbon homes were found to not adequately reduce their environmental impact substantially (Seyfang, 2010). Reaching Finland's ambitious climate neutrality goals might require a stronger focus on household energy behavior. Changing the current household energy behavior will most likely require experimentation the same way other sustainability transitions do.

Though there is a current emphasis on the social challenges and impacts of moving to low carbon society and growing demand from citizens for fairness in the implementation of climate policies (EEA-Eurofound, 2021), only a bit over a third (38%) of the experiments were found to engage with social justice. Accessibility and subsistence, and due process were found to be the most significant social justice categories. Despite the low number of experiments addressing social justice, the presence of these two categories was found to be in line with the EU's just transition focus as fairness and inclusivity that were highlighted in the just transition (see EC, 2019) were connected to these two categories About a fifth of the experiments addressed the justice type of accessibility and subsistence (23%) or due process (20%) respectively. Though the most prominent categories were in line with the just transition focus, it could be debated if the amount of the experiments addressing these themes was in line with that. It needs to be noted that, for example, participation and equal opportunities are the base values of a Nordic democratic welfare state (see, for example, Kuitunen, 2019).

The adequacy of the sufficient depth of these engagements can also be debated. For example, when student housing (Puuseppä) was constructed using low carbon technologies and taking disabilities into consideration, which met the criterion for addressing accessibility and subsistence in this study. In the design of another student housing (HOAS Tuuliniitty), the low carbon desires of generation Z were considered (Kylkilahti et al., 2020), which met the criterion for addressing due process in this study. In these situations, the actual students living in these low carbon buildings did not have a say about their wishes. The actual residents also maybe did not even have a choice whether to live in the low carbon student housing as it could have been the only option for them. These factors made these kinds of cases not fully meet all the aspects that form socially just due process (see Sovacool & Dworkin, 2015).

Most of the cases experimented with only low carbon solutions (78%), and though social justice was addressed in some of them, the focus was on low carbon experimentation. In these experiments, it could be said that they were not even trying to improve social justice but rather do low carbon in a socially just way. Only a tiny fraction (17%) of the experiments combined both low carbon and social justice aspects. In these and experiments focusing only on social justice (5%), desires to actually improve social justice could be identified. The most ambitious social justice experiments tried to develop new ways of participating and addressing homelessness, for example, but did not attempt to change socio-technical systems. This thesis also found that the themes of accessibility and subsistence (welfare and happiness) and due process (procedural justice) were present in large portions of operational energy cases, but much less in embodied energy cases. This raises the question if there is more need to interact with users in operational energy cases than in embodied energy cases and if this possible need affects these results. McManus et al. (2010) have discussed the disconnect between those who build and those who live in houses. This might be related to the smaller portion of due process cases in embodied than operational energy cases.

The chosen approach to the first research question does have some limitations. The observations of this thesis regarding the first research question are based on an analysis of available experiment descriptions in Finland. Finland's enthusiasm for new technologies (Heiskanen et al., 2017) and the culture of experimentation (Prime Minister's Office, 2015) have possibly affected the quantity and availability of information about past and current experiments. As a limitation to this study, it needs to be noted that the experiment data most likely contains distortions as some types of experiments are probably under or over reported. For example, the promotion of wood as a building material (e.g., Finnish Government, 2019) might have given rise not only to the wood construction experiments but also to their reporting. The chosen framework proved to be effective in mapping the different forms of experiments in the built environment by characterizing the ways low carbon and social justice were addressed in the experiments. The limitation of the chosen methodology is that it could not provide in-depth information about the quality of these different aspects.

The results of the mapping showed a large portion of the experiments to be funded, implemented, and intermediated by municipalities. This was not only in line with the previous literature (see, for example, Fuenfschilling et al., 2019) but also showed the importance of understanding the ways municipalities engage in experimentation and what challenges occur in these engagements.

5.2 Municipalities and experimentation

As a second task this thesis interviewed 14 case city (Helsinki, Joensuu, Turku, and Vantaa) officials and other persons working with experimentation and gathered 1 839 pages of case city related documents. The interview transcripts and documents were then analyzed the in an abductive manner to find what kind of policy engagements for experimentation municipalities participated in and what kind of challenges the municipality representatives identified when doing so.

Municipality representatives described that all engagements with experimentation were based on the legally mandated role of the municipality. By law, municipalities should promote (a) the well-being of their residents and (b) the vitality of their area, and (c) organize services for their residents in an economically and environmentally sustainable way (Ministry of Finance, 2015). In all the experiments, municipality representatives described the municipalities to engage in fulfilling at least one of these tasks. Municipality representatives also described that as these were the legally mandated operations of the municipality, they could not fail.

In previous literature, Kivimaa et al. (2017) recognized experiment descriptions to often include subtly interwoven normative values and positive analyses. This was recognized to be the case also in this thesis, as what experiments should do and what they actually do were intertwined in the informants' explanations and additional documents. The difference between these seemed to be unclear to understand or communicate even to some of the informants working with experimentation. This was perceived to be the case, especially when it came to the nature of the experiments and addressing social justice in them. The nature of experiments was defined by the informants to be testing something innovative with the possibility that it might fail, but the actual engagements were often inconsistent with these descriptions. Municipalities engaged in various pilots and projects that they saw as experimentation, but these engagements mostly did not include the possibility of failing (c.f., Sengers et al., 2019) for reasons like linking projects after another (c.f., Munck af Rosenschöld & Wolf, 2017). Municipalities also mostly experimented with solutions that were not novel anymore (c.f., Hildén et al., 2017) but rather something that had been done for several years already. Municipality representatives described that social justice (and through this, the promotion of the wellbeing of the municipality residents) was present in all municipality experimentation. Only about a quarter (26%) of the recognized engagements and challenges were found to be related to the social justice aspects. The actual examples of social justice in EPEs were quite

rare and did not aim to improve the well-being of the residents very radically. In the low carbon experimentation especially, social justice was more of an afterthought or a ticking a box. Rather than aiming to increase social justice, the municipalities aimed to engage in low carbon experimentation in a socially just way.

Municipalities had created internal structures to build and nurture niches. Their main focus was on this first macro process (81%) and especially on the experimentation process rather than the subject matter itself. The process focus can be seen, for example, in the agile piloting model. The model shows institutionalization of the building and nurturing of niche activities. Only about a tenth (11%) of the engagements and challenges had to do with the subject matter (low carbon or buildings). In their experimentation engagements, municipalities focused on the growth of the private sector, and most of the experimentation engagements were placed in their business services department and sought to foster economic growth (c.f., Schot & Steinmueller, 2018). The actual experiments were technology-focused and aimed to create the municipality to be an attractive place for business. Though municipality representatives had wished that the experiments would be upscaled, there was only a little consideration for the requirements of upscaling. In the experiments, economic viability mainly was not considered. This meant that after the experiments finished, they were not necessarily ready to be upscaled without external funding or further business model experimentation, and municipalities offered this kind of experimentation less frequently. It is important to note that there are other outlets of funding and national-level actors (e.g., Business Finland) to scale up businesses.

The municipalities have land, public buildings, and other infrastructure and do public procurement, which means that the municipalities have many opportunities to do experimentation and even upscale their own operations. Especially scaling up could be made easier, especially in the renovation, by utilizing the experiments in their own infrastructure. Despite this, their focus on experimentation engagements was found to be mostly outside their own organization and operations. This could be explained by the fact that the municipality organization is created to fulfill the legally mandated operations of the municipality. The municipality representatives saw that these functions can not fail, which means to them that experimental governance is not suitable for these areas. Municipality interviewees saw the term experiment to be somewhat equivalent to the term project (c.f., Munck af Rosenschöld & Wolf, 2017). In their experimentation, municipalities had largely eliminated the parts they saw as challenging in the municipality context. Uncertainty, failing, scaling up, and shaking the existing structures mainly were excluded from the experimentation engagements of municipalities. A more straightforward way or understanding of experimentation seemed to

have formed based on what kind of experiments municipalities were able to foster and support. This thesis also found that there are several actors and layers of intermediation in the municipalities that engage in experimentation. Rather than being a singular actor or intermediary, as seen in previous literature (e.g., Matschoss & Heiskanen, 2017), municipality governance included multiple actors and intermediaries whose views and engagements in experimentation also differed from each other.

The transformative outcomes framework (Ghosh et al, 2021; Schot et al., 2019) was suitable for characterizing the engagements and challenges but did not guarantee actual sustainability transformation to take place. The framework helped to understand better the types of engagements and challenges. It would be easy to say that the framework was well applicable as the data of this thesis fitted the framework. Despite this, the applicability of the framework can be also questioned. The focus of the framework is on transformative outcomes that would contribute to bigger sustainability transformations. Regardless of this, no evidence was found that these engagements contributed to something transformative. The framework could also be criticized for its base assumptions (see Laatsit et al., 2022). The framework bases itself on the assumption that sustainability transformations form from these transformative outcomes (Ghosh et al, 2021; Schot et al., 2019). Though these engagements can be found in these transformations, there is no evidence that contributing to the transformative outcomes would, without fail, lead to sustainability transformation (see Laatsit et al., 2022). The success of a sustainability transformation also depends on uncertain and random things like timing.

The approach to the second research question was shown to have some limitations. The observations were based on an analysis of municipality actor interviews and municipality documents. The data type that included descriptions rather than observations had possibly affected the results. It was recognized that this type of data had often subtly interwoven normative values and positive analyses (see Kivimaa et al., 2017). This means that a lot of the results were dependent on the researcher's ability to distinguish between what was talked about and what was done regarding experimentation in municipalities. As a further limitation of this study, it needs to be noted this coding work was made by a single researcher so no intercoder reliability can be assessed. Howerver, triangulation was used with the help of additional documents, especially in the cases where these judgments needed to be made. The chosen informants and scope of the study also set some limitations to the results. Other actors would have engaged in different kinds of experimentation and had different views and challenges. In light of the results of this thesis, it also seems that the national level would have been better to

see more of the second and third macro-process though such empirical data collection would go beyond the scope of a single thesis.

The results of the case study showed that municipalities are an essential intermediary in experimentation though not the only one. Municipalities have their own role and scope in the experimentation, but to enable sustainability transitions, they need other actors to work with the same agenda. And moving beyond projectification, it can be debated whether it is the municipality or some other actor that could or should do more to enable sustainability transitions.

5.3 Future research needs

This thesis recognized fruitful areas for future research to generate greater insight on experiments for socially just low carbon buildings and housing. It would be interesting to see (1) how the Finnish results compare with other countries to understand if there are some common or exceptional characteristics in the Finnish experiments when compared to other societies. To create a deeper understanding of the forms of experiments, (2) in-depth studies are needed to look at the actual outcomes of the experiments (e.g., the amount of GHG emission reductions, social justice impacts, and to determine were the experiments successful) as this study could not assess that as the data on the cases mainly did not address these factors. One exciting aspect for future research would be (3) the behavior aspect of these experiments. There has been recognized to be a limited understanding of the interactions between low carbon solutions and occupant behavior both in literature and in practice (e.g., Walker et al., 2014), and the data of this mapping mostly did not address the behavior aspect at all. To enable sustainability transitions, it would be beneficial to understand in what kind of solutions the behavior plays a role and which solutions manage to decrease the impacts of housing even when behavior change does not take place simultaneously.

This thesis also recognized beneficial areas for future research to generate greater insight on the kind of policy engagements for experimentation municipalities participated in and the challenges related to this. It would be interesting to see (1) how the Finnish case results compare with other countries or cities with similar characteristics (such as other Nordic countries or their similar cities) to understand if there are some common or exceptional characteristics in the Finnish cities when compared to other similar municipalities. To create a deeper understanding of the role that the just transition aspect plays in the municipality engagements, (2) interviewing municipality representatives working with social aspects (e.g., homelessness, unemployment, and immigration) would be beneficial as this study focused on

the experimentation and environmental experts. One exciting aspect for future research would be to (3) identify solutions for the challenges the municipalities face when engaging in experimentation. This should be done in close partnership with the city representatives to help them identify and possibly test solutions to the challenges they face in the context of their city strategy.

6 Conclusions

To summarize the findings, this thesis discovered that there is a large focus on building and nurturing niches and testing technologies with a lack of focus on profound social justice and the behavioral side of the sustainability transitions. Regarding the first research question, the results indicated that sustainability experimentation in the built environment is very technology-focused and currently lacks deep engagement with social justice aspects. Even though there were some overlap between low carbon and social justice in the experiments, the mapped experiments did not seek to increase social justice but rather to promote decarbonization in a socially just way. Regarding the second research question, there is evidence that municipalities have a strong focus on building and nurturing niches and pursuing experimentation as a process. Municipality interviewees did not engage in much experimentation themselves, and they focused on the process rather than the subject matter of experimentation. Also, a lack of novelty, flexibility, and low level of tolerance to let experiments fail was found in the analyzed engagements.

The results also reveal that the links between sustainability experimentation and sustainability transitions in practice are not easy to grasp. Though this thesis made an empirical contribution to the field of sustainability experimentation, there remains a need to develop and conduct studies to understand better the phenomena in the socially just low carbon experimentation in the built environment. By doing a just transition to low carbon buildings and housing sector could be accelerated.

7 Acknowledgments

This thesis was conducted as a part of the research project “Citizens as agents of change in decarbonizing suburban and rural housing” (Decarbon-Home). Decarbon-Home is a research consortium project undertaken by the University of Helsinki, Finnish Environment Institute (SYKE), Natural Resources Institute Finland (Luke), University of Vaasa, and Tallinn University of Technology (TalTech, Estonia). The project is funded by the Strategic Research

Council (SRC), established within the Academy of Finland (Grant 335241). (Academy of Finland, 2022.)

Completion of this thesis would not have been possible without the help of project collaborators and supervisors of this thesis. Thank you to the project partner municipalities and everyone who contributed to this thesis by identifying possible interview targets, giving interviews, and providing comments on the research. A special thank you for the excellent advice and critique goes to the supervisors of this thesis, David Lazarevic and Anne Toppinen, who gave their time and support for the thesis writing process.

References

Abrahamse, W., Steg, L., Vlek, C., & Rothengatter, T. (2005). A review of intervention studies aimed at household energy conservation. *Journal of Environmental Psychology*, *25*(3), 273–291. https://doi.org/10.1016/j.jenvp.2005.08.002

Academy of Finland. (2022). *Citizens as agents of change in decarbonizing suburban and rural housing (DECARBON-HOME)*. https://www.aka.fi/en/strategic-research/strategic-research/strategic-research-in-a-nutshell/programmes-and-projects/climate/decarbon-home/

Annala, M., Berg, A., Antikainen, R., Kaskinen, T., Alanko, L., & Leppänen, J. (2016). *Näkökulmia kokeilurahoitukseen – Ehdotus kokeilurahoitusalustan perustamisesta, Valtioneuvoston selvitys- ja tutkimustoiminnan julkaisusarja 14/2016*. http://urn.fi/URN:ISBN:978-952-287-247-0

Annala, M., Kaskinen, T., Seungho, L., Leppänen, J., Mattila, K., Neuvonen, A., Nuutinen, J., Saarikoski, E., & Tarvainen, A. (2015). *Design for Government – kokeiluilla ihmislähtöistä ohjausta, Valtioneuvoston selvitys- ja tutkimustoiminnan julkaisusarja 7/2015*. Demos Helsinki, Avanto Helsinki. http://urn.fi/URN:ISBN:978-952-287-179-4

Ansell, C. K., & Bartenberger, M. (2016). Varieties of experimentalism. *Ecological Economics*, *130*, 64–73. https://doi.org/10.1016/j.ecolecon.2016.05.016

Antikainen, R., Alhola, K., & Jääskeläinen, T. (2017). Experiments as a means towards sustainable societies – Lessons learnt and future outlooks from a Finnish perspective. *Journal of Cleaner Production*, *169*, 216–224. https://doi.org/10.1016/j.jclepro.2017.06.184

Antikainen, R., Kangas, H.-L., Alhola, K., Stenvall, J., Leponiemi, U., Pekkola, E., Rannisto, P.-H., & Poskela, J. (2019). *Kokeilukulttuuri Suomessa – nykytilanne ja kehittämistarpeet, Valtioneuvoston selvitys- ja tutkimustoiminnan julkaisusarja 2/2019*. https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/161281/2-2019-KOKSU_raportti_.pdf

Avelino, F., Dumitru, A., Cipolla, C., Kunze, I., & Wittmayer, J. (2020). Translocal empowerment in transformative social innovation networks. *European Planning Studies*, *28*(5), 955–977. https://doi.org/10.1080/09654313.2019.1578339

Berg, A., Hildén, M., & Lahti, K. (2014). *Kohti kokeilukulttuuria: Analyysi Jyväskylän resurssiviisaista kokeiluista strategisen kehittämisen työkaluina*. https://www.sitra.fi/app/uploads/2014/05/Selvityksia77.pdf

Bulkeley, H., & Castán Broto, V. (2013). Government by experiment? Global cities and the governing of climate change. *Transactions of the Institute of British Geographers*, *38*(3), 361–375. https://doi.org/10.1111/j.1475-5661.2012.00535.x

Cabeza, L. F., Barreneche, C., Miró, L., Morera, J. M., Bartolí, E., & Inés Fernández, A. (2013). Low carbon and low embodied energy materials in buildings: A review. In *Renewable and Sustainable Energy Reviews* (Vol. 23, pp. 536–542). https://doi.org/10.1016/j.rser.2013.03.017

Caniglia, G., Schäpke, N., Lang, D. J., Abson, D. J., Luederitz, C., Wiek, A., Laubichler, M. D., Gralla, F., & von Wehrden, H. (2017). Experiments and evidence in sustainability science: A typology. *Journal of Cleaner Production*, *169*, 39–47. https://doi.org/10.1016/j.jclepro.2017.05.164

Castán Broto, V. (2012). Social housing and low carbon transitions in Ljubljana, Slovenia. *Environmental Innovation and Societal Transitions*, *2*, 82–97. https://doi.org/10.1016/j.eist.2012.01.001

Castán Broto, V., & Bulkeley, H. (2013). *A survey of urban climate change experiments in 100 cities*. *23*, 92–102. https://doi.org/10.1016/j.gloenvcha.2012.07.005

Chen, Q., Kamran, S. M., & Fan, H. (2019). Real estate investment and energy efficiency: Evidence from China's policy experiment. *Journal of Cleaner Production*, *217*, 440–447. https://doi.org/10.1016/j.jclepro.2019.01.274

Dixit, M. K., Fernández-Solís, J. L., Lavy, S., & Culp, C. H. (2012). Need for an embodied energy measurement protocol for buildings: A review paper. *Renewable and Sustainable Energy Reviews*, *16*(6), 3730–3743. https://doi.org/10.1016/j.rser.2012.03.021

EC. (2019). *Communication from the Commission, The European Green Deal, COM/2019/640*. European Commission. https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f-01aa75ed71a1.0002.02/DOC_1&format=PDF

EC. (2021). *Factsheet – Energy Performance of Buildings, FS/21/6691*. European Commission. https://doi.org/10.2775/03938

EEA-Eurofound. (2021). Exploring the social challenges of low-carbon energy policies in Europe. *Publications Office of the European Union Briefing*, *11*. https://doi.org/10.2800/86682

EU. (2010). Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings. *Official Journal of the European Union*, *153*, 13–35. https://eur-lex.europa.eu/eli/dir/2010/31/oj

EU. (2018). Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency. *Official Journal of the European Union*, *156*, 75–91. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2018.156.01.0075.01.ENG

Finnish Government. (2019). *Programme of Prime Minister Sanna Marin's Government 10 December 2019, Inclusive and competent Finland – a socially, economically and ecologically sustainable society, Publications of the Finnish Government 2019:33*. http://urn.fi/URN:ISBN:978-952-287- 811-3

Forsström, J., Lahti, P., Pursiheimo, E., Rämä, M., Shemeikka, J., Sipilä, K., Tuominen, P., & Wahlgren, I. (2011). *Measuring energy efficiency Indicators and potentials in buildings, communities and energy systems, VTT Research Notes 2581*. VTT.

Fuenfschilling, L., Frantzeskaki, N., & Coenen, L. (2019). Urban experimentation & sustainability transitions. *European Planning Studies*, *27*(2), 219–228. https://doi.org/10.1080/09654313.2018.1532977

Geels, F., & Raven, R. (2006). Non-linearity and Expectations in Niche-Development Trajectories: Ups and Downs in Dutch Biogas Development (1973–2003). *Technology Analysis & Strategic Management*, *18*(3–4), 375–392. https://doi.org/10.1080/09537320600777143

Geels, F. W., & Schot, J. (2007). Typology of sociotechnical transition pathways. *Research Policy*, *36*(3), 399–417. https://doi.org/10.1016/j.respol.2007.01.003

Ghosh, B., Kivimaa, P., Ramirez, M., Schot, J., & Torrens, J. (2021). Transformative Outcomes: Assessing and Reorienting Experimentation with Transformative Innovation Policy. *Science and Public Policy*, *48*(5), 739–756. https://doi.org/10.2139/ssrn.3686077

Gillham, B. (2005). *Research interviewing: the range of techniques*. Open University Press.

Heiskanen, E., Hyvönen, K., Laakso, S., Laitila, P., Matschoss, K., & Mikkonen, I. (2017). Adoption and use of low-carbon technologies: Lessons from 100 finnish pilot studies, field experiments and demonstrations. *Sustainability*, *9*(5). https://doi.org/10.3390/su9050847

Heiskanen, E., Nissilä, H., & Lovio, R. (2015). Demonstration buildings as protected spaces for clean energy solutions - The case of solar building integration in Finland. *Journal of Cleaner Production*, *109*, 347–356. https://doi.org/10.1016/j.jclepro.2015.04.090

Heldeweg, M. A. (2017). Legal regimes for experimenting with cleaner production – Especially in sustainable energy. *Journal of Cleaner Production*, *169*, 48–60. https://doi.org/10.1016/j.jclepro.2016.11.127

Hildén, M., Jordan, A., & Huitema, D. (2017). Special issue on experimentation for climate change solutions editorial: The search for climate change and sustainability solutions - The promise and the pitfalls of experimentation. *Journal of Cleaner Production Journal*, *169*, 1–7. https://doi.org/10.1016/j.jclepro.2017.09.019

Hirvonen, J., Jokisalo, J., Heljo, J., & Kosonen, R. (2019). Towards the EU emissions targets of 2050: optimal energy renovation measures of Finnish apartment buildings. *International Journal of Sustainable Energy*, *38*(7), 649–672. https://doi.org/10.1080/14786451.2018.1559164

IPCC. (2014). Summary for Policymakers. In O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel, & J. C. Minx (Eds.), *Climate Change 2014: Mitigation of Climate Change, Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 1–30). Cambridge University Press.

Julien, H. (2008). Content Analysis. In L. Given (Ed.), *The SAGE Encyclopedia of Qualitative Research Methods* (pp. 121–122). SAGE Publications Ltd. https://doi.org/10.4135/9781412963909.n65

Kalaiselvam, S., & Parameshwaran, R. (2014). Applications of Thermal Energy Storage Systems. In *Thermal Energy Storage Technologies for Sustainability* (pp. 359–366). Elsevier. https://doi.org/10.1016/B978-0-12-417291-3.00015-3

Kanger, L., Sovacool, B. K., & Noorkõiv, M. (2020). Six policy intervention points for sustainability transitions: A conceptual framework and a systematic literature review. *Research Policy*, *49*(7), 104072. https://doi.org/10.1016/j.respol.2020.104072

Kemp, R., Schot, J., & Hoogma, R. (1998). Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. *Technology Analysis & Strategic Management*, *10*(2), 175–198. https://doi.org/10.1080/09537329808524310

Kivimaa, P., Boon, W., Hyysalo, S., & Klerkx, L. (2019). Towards a typology of intermediaries in sustainability transitions: A systematic review and a research agenda. *Research Policy*, *48*(4), 1062–1075. https://doi.org/10.1016/J.RESPOL.2018.10.006

Kivimaa, P., Hildén, M., Huitema, D., Jordan, A., & Newig, J. (2017). Experiments in climate governance – A systematic review of research on energy and built environment transitions. *Journal of Cleaner Production*, *169*, 17–29. https://doi.org/10.1016/j.jclepro.2017.01.027

Kronsell, A., & Mukhtar-Landgren, D. (2018). Experimental governance: the role of municipalities in urban living labs. *European Planning Studies*, *26*(5), 988–1007. https://doi.org/10.1080/09654313.2018.1435631

Kylkilahti, E., Berghäll, S., Autio, M., Nurminen, J., Toivonen, R., Lähtinen, K., Vihemäki, H., Franzini, F., & Toppinen, A. (2020). A consumer-driven bioeconomy in housing? Combining consumption style with students' perceptions of the use of wood in multi-storey buildings. *Ambio*, *49*(12), 1943–1957. https://doi.org/10.1007/s13280-020-01397-7

Laakso, S., Berg, A., & Annala, M. (2017). Dynamics of experimental governance: A meta-study of functions and uses of climate governance experiments. *Journal of Cleaner Production*, *169*, 8–16. https://doi.org/10.1016/j.jclepro.2017.04.140

Laatsit, M., Grillitsch, M., & Fünfschilling, L. (2022). *Great expectations: the promises and limits of innovation policy in addressing societal challenges*. http://wp.circle.lu.se/upload/CIRCLE/workingpapers/202209_laatsit.pdf

Markard, J., Raven, R., & Truffer, B. (2012). Sustainability transitions: An emerging field of research and its prospects. *Research Policy*, *41*(6), 955–967. https://doi.org/10.1016/j.respol.2012.02.013

Matschoss, K., & Heiskanen, E. (2017). Making it experimental in several ways: The work of intermediaries in raising the ambition level in local climate initiatives. *Journal of Cleaner Production*, *169*, 85–93. https://doi.org/10.1016/j.jclepro.2017.03.037

Matschoss, K., & Repo, P. (2018). Governance experiments in climate action: empirical findings from the 28 European Union countries. *Environmental Politics*, *27*(4), 598–620. https://doi.org/10.1080/09644016.2018.1443743

McFadgen, B., & Huitema, D. (2018). Experimentation at the interface of science and policy: a multi-case analysis of how policy experiments influence political decision-makers. *Policy Sciences*, *51*(2), 161–187. https://doi.org/10.1007/s11077-017-9276-2

McManus, A., Gaterell, M. R., & Coates, L. E. (2010). The potential of the Code for Sustainable Homes to deliver genuine 'sustainable energy' in the UK social housing sector. *Energy Policy*, *38*(4), 2013–2019. https://doi.org/10.1016/j.enpol.2009.12.002

Ministry of Finance. (2015). *Local Government Act*. *410/2015*. https://www.finlex.fi/en/laki/kaannokset/2015/en20150410.pdf

Ministry of Finance. (2020). *Kunnat käännekohdassa? Kuntien tilannekuva 2020, Valtionvarainministeriön julkaisuja 2020:13*. http://urn.fi/URN:ISBN:978-952-367-065-5

Munck af Rosenschöld, J., & Wolf, S. (2017). Toward projectified environmental governance? *Environment and Planning A*, *49*(2), 273–292. https://doi.org/10.1177/0308518X16674210

Official Statistics of Finland. (2022). *Population structure [e-publication], 11ra – Key figures on population by region, 1990-2020*. https://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin/StatFin__vrm__vaerak/statfin_vaerak_pxt_11ra.px/table/tableViewLayout1/

Ornetzeder, M., & Rohracher, H. (2009). Passive houses in Austria: the role of intermediary organisations for the successful transformation of a socio-technical system. *ECEEE 2009 Summer Studies*, 1531–1540. https://www.eceee.org/static/media/uploads/site-2/library/conference_proceedings/eceee_Summer_Studies/2009/Panel_7/7.175/paper.pdf

Portal, A., Kompatscher, A., & Clark-Foulquier, C. (2021). *Targeting energy efficiency renovation to improve housing conditions of the most vulnerable*. https://www.feantsa.org/public/user/Resources/reports/Targeting_Energy_Efficiency_Renovation_Report.pdf

Prime Minister's Office. (2015). *Finland, a land of solutions: Strategic Programme of Prime Minister Juha Sipilä's Government, Government publications 12/2015*. Edita Prima. https://valtioneuvosto.fi/documents/10184/1427398/Ratkaisujen+Suomi_EN_YHDISTETTY_netti.pdf/8d2e1a66-e24a-4073-8303-ee3127fbfcac

Prime Minister's Office. (2021). Hallituksen esitys eduskunnalle laiksi maankäyttö- ja rakennuslain muuttamisesta. *HE*, *121*. https://www.finlex.fi/fi/esitykset/he/2021/20210121

Reid, L. A., & Houston, D. (2013). Low Carbon Housing: A "Green" Wolf in Sheep's Clothing? *Housing Studies*, *28*(1), 1–9. https://doi.org/10.1080/02673037.2013.729263

Rimpelä, M. (2017). Kokeilukulttuuri – vahvistuva värisävy kehittämisen kirjoissa vai poliittista retoriikkaa? *Yhteiskuntapolitiikka*, *82*(2), 235–236. http://urn.fi/URN:NBN:fi-fe201709058480

Saari, A., Airaksinen, M., Sirén, K., Jokisalo, J., Hasan, A., Nissinen, K., Vainio, T., Möttönen, V.-J., Pulakka, S., Heljo, J., Vihola, J., Vuolle, M., Niemelä, J., Kalliomäki, P., Kauppinen, J., & Haakana, M. (2012). *Energiatehokkuutta koskevien vähimmäisvaatimusten kustannusoptimaalisten tasojen laskenta: Suomi*. https://www.ym.fi/download/Liite_8_Energiatehokkuutta_koskevien_vahimmaisvaatimusten_kustannusoptimaalisten_tasojen_laskenta/6f36df56-7d90-4223-84bf-41f9c4067cce/123867

Sanderson, I. (2002). Evaluation, Policy Learning and Evidence-Based Policy Making. *Public Administration*, *80*(1), 1–22. https://doi.org/10.1111/1467-9299.00292

Sankelo, P., & Alhola, K. (2020). Kohti vähäpäästöistä rakennuskantaa. In *International Journal of Sustainable Energy* (Vol. 38, Issue 7). Taylor and Francis Ltd. https://hiilineutraalisuomi.fi/download/noname/%7BC26B9450-FD8C-4953-9C4D-323014AF6D9A%7D/159436

Schot, J., & Geels, F. (2008). Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy. *Technology Analysis & Strategic Management*, *20*(5), 537–554. https://doi.org/10.1080/09537320802292651

Schot, J., Kivimaa, P., & Torrens, J. (2019). Transforming Experimentation: Experimental Policy Engagements and Their Transformative Outcomes. *TIPC Research Report, March 2019*. http://www.tipconsortium.net/publication/transforming-experimentation-experimental-policy-engagements-and-their-transformative-outcomes/%0Ahttp://www.tipconsortium.net/wp-content/uploads/2019/07/Transforming-Experimentation-Policy-Brief.pdf

Schot, J., & Steinmueller, W. E. (2018). Three frames for innovation policy: R&D, systems of innovation and transformative change. *Research Policy*, *47*(9), 1554–1567. https://doi.org/10.1016/j.respol.2018.08.011

Sengers, F., Wieczorek, A., & Raven, R. P. J. M. (2019). Experimenting for sustainability transitions: a systematic literature review. *Technological Forecasting & Social Change*, *145*, 153–164. https://doi.org/10.1016/j.techfore.2016.08.031

Seppälä, A., Haanpää, S., Klein, J., & Juhola, S. (2017). Kokeilujen kautta hiilineutraaleihin kaupunkeihin? - Ilmastokatu-hankkeen arviointiraportti. *Aalto-Yliopiston Julkaisusarja TIEDE + TEKNOLOGIA*, *2*.

Seyfang, G. (2010). Community action for sustainable housing: Building a low-carbon future. *Energy Policy*, *38*(12), 7624–7633. https://doi.org/10.1016/j.enpol.2009.10.027

Silvast, T. (2014). Sisällönanalyysi. In I. Massa (Ed.), *Polkuja yhteiskuntatieteelliseen ympäristötutkimukseen* (pp. 33–48). Gaudeamus.

Smith, A., & Raven, R. (2012). What is protective space? Reconsidering niches in transitions to sustainability. *Research Policy*, *41*(6), 1025–1036. https://doi.org/10.1016/j.respol.2011.12.012

Sovacool, B. K., & Dworkin, M. H. (2015). Energy justice: Conceptual insights and practical applications. *Applied Energy*, *142*, 435–444. https://doi.org/10.1016/j.apenergy.2015.01.002

Stenvall, J. (2017). *Kokeilut rubikin kuutioina?* Kuntaliitto. https://www.kuntaliitto.fi/julkaisut/2017/1858-kokeilut-rubikin-kuutioina-acta-nro-269

Tassey, G. (2014). Innovation in innovation policy management: The Experimental Technology Incentives Program and the policy experiment. *Science and Public Policy*, *41*(4), 419–424. https://doi.org/10.1093/scipol/sct060

Walker, S. L., Lowery, D., & Theobald, K. (2014). Low-carbon retrofits in social housing: Interaction with occupant behaviour. *Energy Research and Social Science*, *2*, 102–114. https://doi.org/10.1016/j.erss.2014.04.004

Appendices

Appendix A: Experiment databases

Table A1

Experiment mapping databases, accessed during December 2021 and January 2022

Database	Description	Objects	
		Reviewed	Recog-nized
Ara.fi	Database for government supported construction and development projects. Only development projects were reviewed.	54	19
Co2mmunity.eu	Network of organizations in the Baltic Sea Region facilitating community energy project development.	7	4
Energiakokeilut.fi	Database of low carbon technology trials and related article (Heiskanen et al., 2017). Traffic cases were excluded.	105	66
Energialoikka.fi	Database of energy and material wise solutions. Not building related energy solutions were excluded from the review.	265	21
Energiaviisaat.fi	Database of the Energy Wise Cities project pilots.	72	7
Fibgc.fi	Database of publications and references for a sustainable built environment. Also 240 news articles were reviewed.	174	36
Gnf.fi	Green Net Finland database of projects.	27	6
Hiilineutraalisuomi.fi	Database of Canemure and Hinku projects. Projects, subprojects and Hinku award recipients were reviewed.	90	16
Kiradigi.fi	Digitalisation of the built environment and construction sector experiment database.	133	6
Kokeilunpaikka.fi	Library of experiments. Finished experiments in the categories architecture, housing and homelessness were reviewed.	22	5
Materiaalitkiertoon.fi	Database of circular economy projects. Only cases in category construction and land use were reviewed.	17	7
Motiva.fi	Sustainable development company Motiva GreenEnergyCases database and other projects presented on the website.	125	16
Puuinfo.fi	Database of wood architecture and completed projects. Bridges were excluded from the review.	241	24
Sitra.fi	The Finnish Innovation Fund publications database. Only construction related publications were reviewed.	46	27
Smartclean.fi	Database of Helsinki Metropolitan Smart & Clean foundation projects.	8	1
Internet searches, Google Search January 6th 2022	Key search words for experiments (*"innovaatio", "kokeilu", "projekti", "pilotti"*) were paired with building and housing *("asuminen", "rakennus", "rakentaminen"*), low carbon *("hiilineutraali", "vähähiilisyys"*) and case city (*"Helsinki", "Joensuu", "Turku" "Vantaa"*) related words.	NA	9
Total	15 databases, some objects were found in multiple databases	1386	204

During the mapping cases were recognized as experiments in at least one of the following ways:

a) In the project description at least one of the following expressions was used to describe the low carbon and/or social justice experimentation in built environment: "demonstration", "experiment", "field trial", "first", "forerunner", "innovation", "innovative solution", "model solution", "new solution", "pilot", "pioneer", "test", "unique".
b) Heiskanen et al. (2017) had recognized the low carbon and/or social justice experimentation in built environment as an experiment.

In the process of going true the databases the low carbon and/or social justice experimentation in built environment was recognized to be a novel solution.

Appendix B: List of all experiments

The recognized experiments (204) have been listed in Table B1–Table B6. Table B1 lists all the energy efficient building, Table B2 energy efficient district, Table B3 energy management, Table B4 energy renovation, Table B5 renewable energy, and Table B6 social experiments. Following abbreviations have been used in the experiment listing: CC (circular construction), CE (community energy), DH (district heating), EA (energy advice), ESCO (energy service company), HR (heat recovery), HWC (high wood construction), nZEB (nearly zero energy building), PE (participatory experiment), PP (power plant), PV (photovoltaics), RE (renewable energy), VPP (virtual power plant), WC (wood construction), ZEB (zero energy building).

Table B1

List of 81 recognized energy efficient building experiments in the experiment mapping

Energy efficient building experiment		
ATH–KOK	LAK–RAM	RAN–YLÖ
AthLEDics	Lakea	Rantamäki
Circuit Kiasma & HSY CC	Lappeenranta Green Campus	Rantarousti school
Circwaste CC	Lighthouse HWC	Rauduskoivu & Mänty WC
CO2ncrete Solution CC	Lintuviita 2 WC	Recyclable Production Plant CC
Consept Olavilla	Log House ZEB	Ruukki: Solar Roof
DAS Kelo HWC	Luukku WC	S-Market CC
Day Care ZEB	Materiaalitori CC	Sakarinmäki
Digitalization WC	Matrex	Satavuo school WC
Emission-free construction site	Mestariasunnot	SATO Demolition CC
ESCO Buyer	Mestaritorppa nZEB	Straw Bale House
ESCO Provider	Metsäkissa	Sunsampo
Event CC	Neapo	Swimming hall PV
Geopolymer Composite	Onnelanpolku ZEB	SYKE CC
Greenest of the greens	PHOK	TAPRE
Guide Piloting ZEB	Pihapetäjä WC	Teemu Varpanen PV
HAMK Ruukki nZEB	Porvoo daycare	Tikkurila Dixi
HOAS Tuuliniitty WC	Puhas Oy CC	Toriparkki ZEB
Honkasuo HWC	Puu-Paavola WC	Transformation elasticity WC
House 2020	PuuEra HWC	Trekoli WC
House A	Puukuokka 1 HWC	Tuupala school WC
House Korea	PuuMERA HWC	Vaaralanpuisto day care
Hyppy demolition CC	Puuseppä Student Housing ZEB	Verso WC
Jampankaari elderly home ZEB	PV purchasing	Vihta WC
Joint Space Project CE	Pyörre CC	Viikki Environment House ZEB
Kaaripolku service home	Rajamiehentie WC	Villa Isover ZEB
KBB	Rakuunantie 1 WC	Wasa Station
Kokoon WC	RAMPO CC	Ylöjärvi Ice Hall

Table B2

List of 28 recognized energy efficient district experiments in the experiment mapping

Energy efficient district experiments		
ARC–KAU	KER–PEL	RAN–ÖST
Arctic Smart Village	Kera Challenge	Rantakylä-Utra
Design principles	Kuninkaantammi	Ravilaakso CC
Finnoo	Kytkin Project	Resource Wise Henna
GeoHouse Smart City	Land transfer	Satamalahti
Helsinki Innovation Districts	Linnanfält	Skaftkärr
Hiukkavaara	Mellunmäki	Tampere Hiedanranta
Härmälänranta	Meri-Rastila OurCity	Tarmo
Ilokkaanpuisto	MyTown Tuusula	Östersundom Smart and Clean
Isokuusi	Nurmi-Sorila	
Kaukovainio	Peltosaari	

Table B3

List of 20 recognized energy management experiments in the experiment mapping

Energy management experiments		
ADJ–HEA	IOT–SAV	SER–WAT
Adjutantti	IoT-sensor	Service building VPP
Demand response	Kuopio Hall VPP	Siemens Sello VPP
Digitalizing	Machine Learning	The Natural Step
Energy saving pilot	NB-IoT Talotohtori	Varaamo
Euronet 50–50	Oulu energy: solar pilot	Virpa demand response
Fortum: Home Display	PowerBI	Water heater
Heating managment	Save Energy	

Table B4

List of 17 recognized energy renovation experiments in the experiment mapping

Energy renovation experiments		
CAF–INN	JUU–LOW	POH–VIR
Cafe Carusel PV	Juustilankatu 9	Pohjolankatu 18-20
EEMontti	Kummatti CC	Renovation Leap
Haikola Hybrid System PV	Laakso Hospital CC	Senaatti RE
Heka innovation	Lock recycling CC	Smart fans
Hämeenpuisto 21 PV	Lokkisaarentie	Virkakatu 8
Innova house	Low Carbon Solutions	

Table B5

List of 34 recognized renewable energy experiments in the experiment mapping

Renewable energy experiments		
ALP–HUS	INT–PIT	PIT–WAS
Alpua Village CE	Integration into Structures PV	Pitkäniemi DH
Demand Response DH	Joint Purchasing PV	S-market HR DH
DH Data Center HR	Katri Valan DH PP	Sarankulma DH PP
Elwedo PV	Kempele Eco-village CE	Savilahti DH
Flamingo HR	Kesko HR	Savumax HR
Haapalahdenkatu 11 CE	Kokkosenlahti CE	Skanssi DH
Heat Control Service HR	LEMENE-project CE	Solarvoima PV
Heat Storage DH	Lämpöä DH	Solixi PV
Helen Salmisaari DH PP	Minerva & DNA HR	Suvilahti DH
Housing Co-operative PV	Optimization DH	Waste Water HR DH
Hukaton HR	Optimization DH	
Husulanmäki CE	Pitkäkoski HR	

Table B1

List of 24 recognized social experiments in the experiment mapping

Social experiments		
ART–ENE	GRA–MÄN	NAK–TUR
Artificial Inteligence EA	Granlund PE	Naksu
Climate Street EA	HEA project	Nudge EA
Communal Housing	Heka Eco-Expert App EA	Sammonlahti PE
Digitalization of Service Housing	Housing and Work	Smart and Wise Turku
EA Event	HSY Open data EA	Sompasauna
Energy Certificate Law	KATI	Sound Lighthouse
Energy-Essi EA	Multigeneraition Building	Sustainable living EA
Energy-expert EA	Mäntykampus	Turku PE

Appendix C: Experiment timing

Timing of the experiments has been portrayed in Figure C1 and Figure C2. Year or years when the experiments took place has been illustrated in Figure C1. Duration of the experiments has been presented in Figure C2.

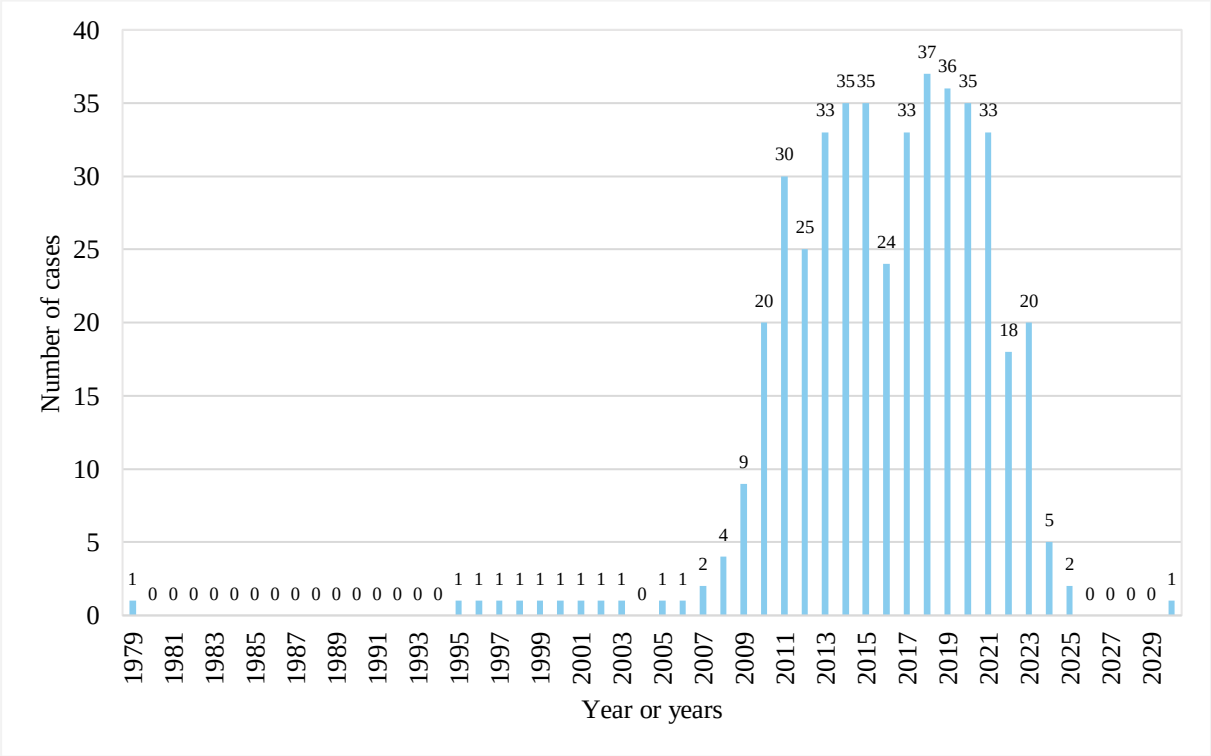

Figure C1. Experiment timing

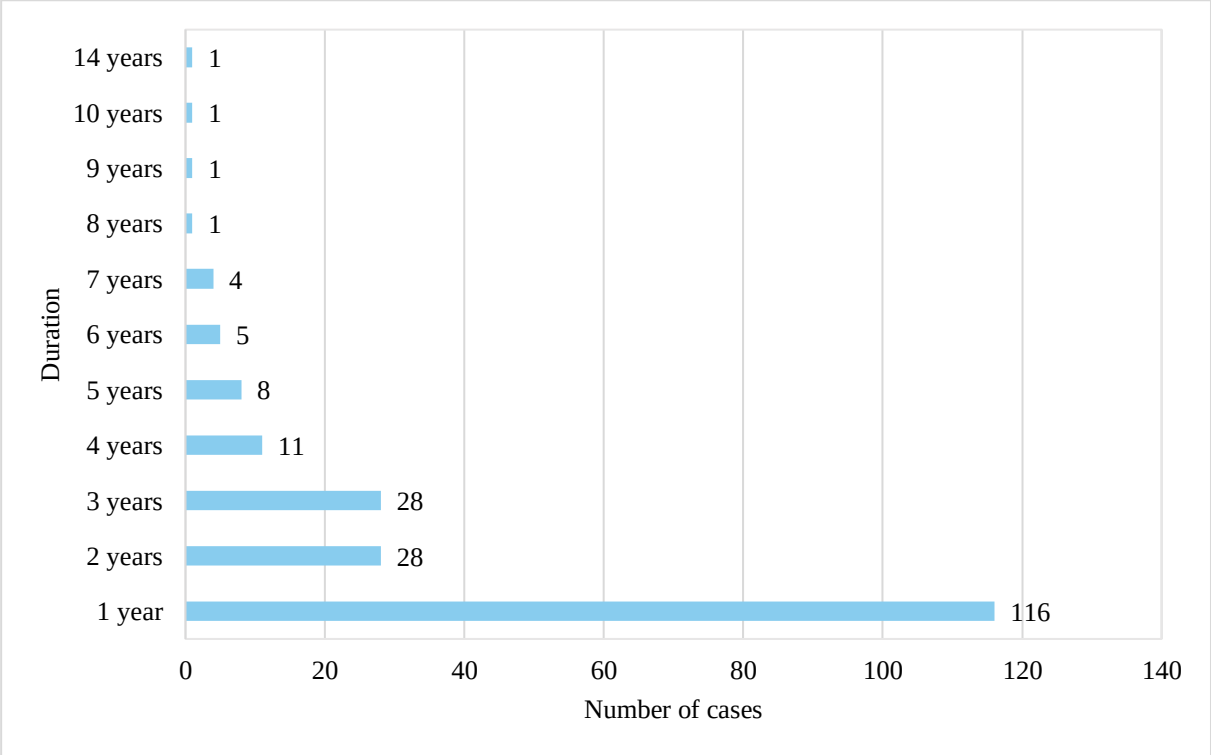

Figure C2. Duration of the experiments (during how many years the experiment took place, the actual length was not necessarily full years

Appendix D: Experiment location

The experiment locations presented in Table D1 were categorized based on the municipality or municipalities where the experiment took place. Region or regions where the experiment took place were used if specific municipality data wasn't available or the experiments took place in the whole region or regions. Municipalities were allocated into seven categories constructed by the Ministry of Finance (2020) based on the population of the municipality (Official Statistics of Finland, 2022). The population data was based on the population from end of year 2020 and uses municipal division from start of year 2021. Experiments were also identified as urban or rural. Urban experiments were divided further into urban (only city center experiments) and suburban (experiments in the suburbs and in the outskirts of cities).

Table D1

Location of the experiments

Size	Municipality or region	Urban	Suburban	Rural	NA	Total
Region	Central Finland (2), Coastal Ostrobothnia (2), Häme region (1), Metropolitan area (3), Päijät-Häme (1), Satakunta (2), South Karelia (2), South Ostrobothnia (1), South Savo (1), Tampere region (4)	1	4	0	5	9
100 000– residents	Espoo (9), Helsinki (48), Jyväskylä (5), Kuopio (4), Lahti (7), Oulu (7), Tampere (12), Turku (11), Vantaa (14)	29	69	2	21	111
40 001– 100 000 residents	Hyvinkää (2), Hämeenlinna (2), Joensuu (5), Järvenpää (5), Kouvola (2), Lappeenranta (5), Lohja (1), Mikkeli (2), Pori (4), Porvoo (6), Rovaniemi (1), Salo (1), Seinäjoki (1), Vaasa (4)	8	25	0	6	39
20 000– 40 000 residents	Imatra (1), Jämsä (1), Kajaani (2), Lempäälä (1), Mäntsälä (2), Nokia (1), Raahe (2), Rauma (1), Riihimäki (2), Siilinjärvi (2), Sipoo (1), Tuusula (1), Ylöjärvi (1)	1	10	2	5	18
10 001– 20 000 residents	Forssa (1), Heinola (1), Kempele (1), Kontionlahti (1), Laukaa (1), Liperi (1), Orimattila (1), Pirkkala (1), Uusikaupunki (1), Ylivieska (1)	0	4	2	3	9
5 001– 10 000 residents	Ii (1), Kuhmo (1), Laihia (1), Mynämäki (1), Nurmes (2), Outokumpu (1), Pudasjärvi (1), Tyrnävä (1), Virrat (1)	0	1	7	2	10
2 000–5 000 residents	Ilomantsi (1), Kuhmoinen (1), Lapinjärvi (1), Petäjävesi (1), Polvijärvi (1), Rääkkylä (1), Toivakka (1), Urjala (1), Utajärvi (1)	0	1	5	1	7
–2 000 residents	Kannonkoski (1), Multia (1)	0	0	1	0	1
NA	Not local or not specified	0	0	1	14	15
Total		39	112	18	47	204

Appendix E: Experiment stakeholders

Different types of stakeholders were recognized in the experiments. Stakeholders were categorized into eight categories: EU, government, municipality, nonprofit, research, business, association, and resident. All types of funding from the European Union were included into category "EU". Finnish government, ministries, and government owned functions were included into category "government". Municipality and municipality owned functions were combined to category "municipality". Category "nonprofit" was combined from treasuries, trusts, and non-profit organizations. Universities, universities of applied science, and other research related functions were incorporated into category "research". Category "business" was used to cover privately owned business, "association" associations, co-operations, and housing companies, and "resident" private citizens, households, and residents. Stakeholders were considered as financiers and/or participants. Allocation into these categories is presented in Table E1.

Table E1

Experiment financiers and participants

Financier	Participant								Total
	EU	Government	Municipality	Non-profit	Re-search	Business	Association	Resident	
EU	0	2	32	12	16	27	10	10	45
Government	0	23	18	6	8	26	8	13	43
Municipality	0	6	60	8	4	34	7	11	62
Nonprofit	0	4	14	14	1	18	6	7	25
Research	0	0	0	0	4	1	0	0	4
Business	0	5	14	2	5	49	5	7	50
Association	0	0	3	0	0	10	12	6	13
Resident	0	0	0	0	0	13	4	16	17
Total	0	30	106	30	29	137	40	55	204

Appendix F: Experiment building types

Cases were categorized by the building type into two categories (“residential”, “other”) and further into specific subcategories. Experiments were also placed into categories based on the type of build (“new build”, “renovation”, “demolition”). In some cases, there was no available information about the type of building or build and these cases were categorized into their own category “not specified”. Data is partially overlapping as some cases included multiple types of building and or build. Ten cases included building types from both main categories “residential” and “other”. Allocation into these categories is presented in Table F1. In case of the residential buildings (117 cases) the ownership status of the apartments was inspected. Ownership of the residential apartments is presented in Figure F1. The numbers represent total cases in each category.

Table F1

Type of build and building in the experiments

Type of building		Type of build			
Type	Subtype	New Build	Renovation	Demolition	NA
Residential (117)	Single-family detached (25)	16	4	1	5
	Single-family attached (6)	1	2	0	3
	Large multi-family (56)	26	18	5	9
	Residential district (29)	20	2	1	8
	Not specified residential (7)	1	1	0	6
Other (86)	Commercial (19)	6	7	1	6
	Industrial (5)	2	1	0	2
	Infrastructure (16)	13	3	0	1
	Agricultural (2)	0	1	0	1
	Institutional (49)	23	21	4	7
	Nonresidential district (4)	1	0	0	3
NA (11)	Not specified (11)	3	1	2	7
Total		105	54	11	48

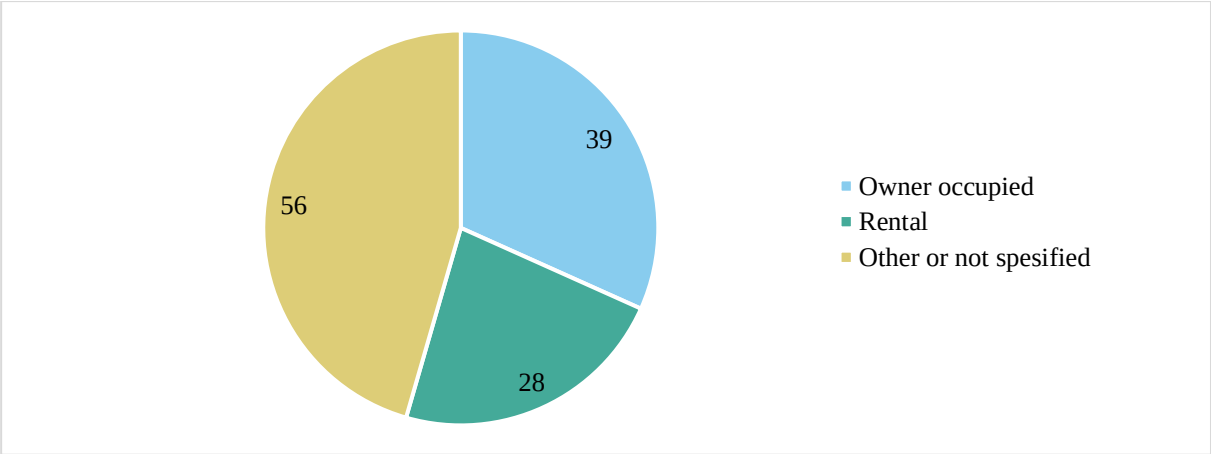

Figure F1. Ownership of the residential apartments

Appendix G: Low carbon and social justice in the experiments

The types of low carbon and social justice present were evaluated in the recognized experiments. Occurrence of these categories in the experiment mapping is presented in Table G1in more detail.

Table G1

Type of low carbon and social justice in the experiments

Low carbon		Type of social justice									All
Type	Subtype	Resource egal-itari-anism	Effi-ciency	Human rights and social con-flict	Due pro-cess	Accessib ility and sub-sisten ce	Subsid ies	Resour ce egalita rian-ism	Intergen era-tional equity	N A	
Embod-ied en-ergy	Building ma-terial pro-duction	8	0	0	12	6	0	41	3	4	58
	On-site delivery	1	0	0	1	0	0	5	0	0	6
	Construction	6	0	0	0	0	0	11	0	0	13
	Maintenance	1	0	0	0	0	0	2	0	0	3
	Renovation	3	0	0	1	1	0	11	0	0	12
	Final demolition	3	0	0	0	0	0	12	0	0	12
	Not specified embodied energy	1	0	0	2	2	0	14	0	1	15
	Total	13	0	0	13	8	0	62	3	5	79
Opera-tional energy	Energy design	7	0	0	2	3	0	22	0	3	26
	Passive com-ponents	1	0	0	2	4	0	17	0	4	20
	Insulation/air tightness	6	0	0	5	7	1	18	0	3	23
	Building services	22	0	0	8	7	1	40	0	4	47
	Use of renewable energy	36	0	0	15	17	1	80	6	9	95
	Energy man-agement	44	0	0	14	11	1	72	1	4	83
	Energy behavior	12	0	0	4	9	0	5	0	0	13
	Not specified operational energy	13	0	0	8	9	0	34	0	1	39
	Total	68	0	0	31	34	1	130	6	10	156
NA		0	2	0	4	9	1	0	0	0	11
All		76	2	0	40	46	2	153	8	13	204

Appendix H: Interview guide

The literature review and chosen framework guided the interviews to focus on (a) the types of experimental policy engagements cities undertake, (b) the challenges cities face when engaging in experimental governance, (c) the types of transformative outcomes experimental policy engagements target, and (d) the challenges governance experiments face beyond niche construction. The full interview guide used in the interviews of this thesis, is presented below.

Interview guide

"In this interview I would like to talk with you about experimentation, the different types of actions your organization/department takes to engage with and supports experimentation, and the outcomes of experimentation."

Role & organization

1. Can you tell about your role in the city administration and its relation to experimentation? What are the specific factors you use to define an experiment?
2. In general, how does the city structure or organize its experimentation/piloting activities and who is responsible for these actions?

Types of experiments & building and nurturing niches

3. What types of experiments that support low carbon buildings does the city promote or undertake, can you give some concrete examples?
4. What **actions** have been undertaken to facilitate and scale experimentation?
5. What have been the key **lessons** learnt for city to support experimentation and scaling?
6. What **challenges** have arisen during these experimentation processes?
7. What are some concrete **outcomes** from these experiments?

Policy/governance experimentation & experimental governance culture

8. Does the city carry out any policy experimentation or experiment with new processes, and what **actions** have been undertaken to facilitate this experimentation?
9. What have been the key **lessons** learnt from these actions in terms of potential for policy change?
10. What **challenges** have arisen during these experimentation processes?
11. What are some concrete **outcome**s from these experiments?

Multi-regime, goals & social sustainability

12. From your experience, do you think experimentation naturally fit to some sectors and not others?
13. Have you experienced any 'culture clash' between different administrative units/departments concerning experimentation?
14. How do you integrate sustainable development into your programs?
15. Is social sustainability addressed and, if so, how?
16. Are there any experiments with dual goals of environmental and social sustainability?

Appendix I: Municipality informants and additional documents

Information sources (informants and additional documents) used in the analysis to answer the second research question have been listed below under case city categories. Additional documents were identified through informant recommendations and internet searches. Documents, that interviewees mentioned in the interviews and communications prior to the interviews, were gathered. From the internet searches case city related municipal strategy, experimental policy engagement, low carbon and social justice related documents were gathered. Internet searches were done on January 30th, 2022, with Google Search to identify case city related documents. Key search words for municipal strategy (*"strategia"*), experimental policy engagement (*"innovaatio", "kokeilu", "projekti", "pilotti")*, low carbon *("hiilineutraali", "vähähiilisyys"*) and social justice (*"hyvinvointi", "osallistaminen", "osallistamis", "sosiaali", "terveys", "vaikuttamis"*) were paired with case city names.

From additional documents relevant parts to analyze were recognized by using the forementioned key search words for experimental policy engagement, low carbon, and social justice. For documents in Finnish above mentioned terms were used and for documents in English equivalent terms for experimental policy engagement ("*innovation*", "*experiment*", "*project*", "*pilot*", "*trial*"), low carbon ("*low carbon*", "*carbon neutral*"), and social justice ("*wellbeing*", "*participating*", "*participation*", "*social*", "*health*", "*empowerment*", "*equal*", "*just*", "*justice*") were used. In addition to these search term "*housing*" ("*asuminen*" in Finnish documents) was used. The searches were made covering all the variants of these terms.

Helsinki

H1–H6 Informants

H7. 6Aika. (2021). *Era of Cities, The joint development of the Six Cities within the Six City Strategy*. The Six City Strategy Office. https://drive.google.com/file/d/10rVW-LOKVa9fSvOBPmDYv3Rid6d4z6kS/view

H8. Bergström, M. (2015). Smart City Living Lab – City as a place. In P. Ballon, A. Garcia, T. Hirvikoski, M. Holst, P. Krawczyk, S. Leminen, A. Serra, A. Ståhlbröst, J. Stewart & S. van der Graaf (eds.), *Research Day Conference proceedings 2015*, OpenLivingLab Days (p. 47–55). European Network of Living Labs. https://issuu.com/enoll/docs/276089123-enoll-research-day-conference-proceeding

H9. City of Helsinki. (2017). *The Most Functional City in the World, Helsinki City Strategy 2017–2021*. https://www.hel.fi/static/helsinki/kaupunkistrategia/strategia-en-2017-2021.pdf

H10. City of Helsinki. (2018a). *Hyvinvoinnin ja terveyden edistämisen (HYTE) johtaminen ja koordinointi Helsingissä*. https://www.hel.fi/static/helsinki/kaupunkistrategia/karki/hyte/hyte-raportti.pdf

H11. City of Helsinki. (2018b). *The Carbon-neutral Helsinki 2035 Action Plan, publications of the Central Administration of the City of Helsinki 2018:4*. https://www.hel.fi/static/liitteet/kaupunkiymparisto/julkaisut/julkaisut/HNH-2035/Carbon_neutral_Helsinki_Action_Plan_1503019_EN.pdf

H12. City of Helsinki. (2019a). *Agendasta teoiksi, YK:n kestävän kehityksen tavoitteiden toteutuminen Helsingissä 2019*. https://www.hel.fi/static/helsinki/julkaisut/SDG-VLR-Helsinki-2019-fi.pdf

H13. City of Helsinki. (2019b). *Health and well-being for everyone, The welfare plan of the City of Helsinki 2019–2021*. https://www.hel.fi/static/liitteet-2019/Helsinki/hyte/hytehyvinvointisuunnitelmaenglish.pdf

H14. City of Helsinki. (2019c). *Infographic of the City of Helsinki's procurement process for EdTech companies*. Education Division. https://www.oppimisenuusiaika.fi/wp-content/uploads/2019/06/Infograafi_EN_web.pdf

H15. City of Helsinki. (2019d). *Maailman toimivin kaupunki, Kestävän kehityksen tavoitteet, Kaupunkitasoisen toimeenpanoraportin ensimmäinen osa*. https://www.hel.fi/static/helsinki/julkaisut/helsinki-sdg-raportoinnin-osa-1.pdf

H16. City of Helsinki. (2019e). *Maailman toimivin kaupunki, Kestävän kehityksen tavoitteet, Kaupunkitasoisen toimeenpanoraportin toinen osa*. https://www.hel.fi/static/helsinki/julkaisut/helsinki-sdg-raportoinnin-osa-2.pdf

H17. City of Helsinki. (2021). *A place of growth, Helsinki City Strategy 2021-2025*. https://www.hel.fi/static/kanslia/Julkaisut/2021/helsinki-city-strategy-2021-2025.pdf

H18. Heiskanen, E., Laakso, S., Apajalahti E.L. & Matschoss K. (2019). *Living lab country report – Finland*. ENERGISE project. https://zenodo.org/record/3354053#.XWzAcugzZaQ

H19. Matschoss, K., Korhonen, K. & Heiskanen, E. (2016). *Kalasatama*. Aalto University, CROSSOVER 13/2016. http://urn.fi/URN:ISBN:978-952-60-7210-4

H20. Mobility Lab Helsinki. (2022). *Jätkäsaari Mobility Lab – Kaksivaiheinen nopeiden kokeilujen malli*. https://mobilitylab.hel.fi/app/uploads/2022/05/Nopeiden-kokeilujen-kaksivaiheinen-malli-Ja%CC%88tka%CC%88saari-Mobility-Lab-FINAL.pdf

H21. Mustonen, V. (2015). Creating a Smart City Vision in a Living Lab – Case Study of Smart Kalasatama Vision-building Process. In P. Ballon, A. Garcia, T. Hirvikoski, M. Holst, P. Krawczyk, S. Leminen, A.

Serra, A. Ståhlbröst, J. Stewart & S. van der Graaf (eds.), *Research Day Conference proceedings 2015*, OpenLivingLab Days (p. 156–167). European Network of Living Labs. https://issuu.com/enoll/docs/276089123-enoll-research-day-conference-proceeding

H22. Mustonen, V., Spilling, K. & Bergström, M. (2019). *Cookbook, recipes for agile pilots*. Forum Virium Helsinki, Smart Kalasatama. https://6aika.fi/wp-content/uploads/2019/06/Smart_Kalasatama_Agile_Pilots_CookBook.pdf

H23. mySMARTLife. (2018). *Transition of EU cities towards a new concept of Smart Life and Economy, D1.14 Techno-economic analysis of each intervention per pilot*. https://www.mysmartlife.eu/fileadmin/user_upload/publications/D1.14_Techno-economic_analysis_of_each_intervention_per_pilot.pdf

H24. Saikkonen, P., Hannikainen, K., Kauppinen, T., Rasinkangas, J. & Vaalavuo, M. (2018). *Sosiaalinen kestävyys: asuminen, segregaatio ja tuloerot kolmella kaupunkiseudulla*. Finnish institute for health and welfare, report 2/2018. https://research.utu.fi/converis/portal/detail/Publication/38993067?lang=fi_FI

H25. Seppälä, A., Haanpää, S., Klein, J. & Juhola, S. (2017). *Kokeilujen kautta hiilineutraaleihin kaupunkeihin? Ilmastokatu-hankkeen arviointiraportti*. Aalto University, Department of Built Environment. http://urn.fi/URN:ISBN:978-952-60-7604-1

H26. Spilling, K. & Rinne, J. (2020). *Pocket Book for agile Piloting, Facilitating co-creative experimentation*. Forum Virium Helsinki. https://drive.google.com/file/d/1L7c-FEUOFfvWQE3am35SYk-4bvJPz7RH/view

Joensuu

J1–J2 Informants

J3. City of Joensuu. (2016). *Osallistuva ja kehittyvä kaupunkimaaseutu, Joensuun maaseutuohjelma vuosille 2016–2020*. https://www.joensuu.fi/documents/144181/2332332/Joensuun+maaseutuohjelma+2016-2020.pdf/d38faa30-87cd-f8b2-422c-866a1e494f04?version=1.0

J4. City of Joensuu. (2021a). *Hiilineutraali Joensuu 2025, Joensuun kaupungin ilmasto-ohjelma 2022–2025*. https://climatejoensuu.fi/documents/3877132/0/Joensuun+kaupungin+ilmasto-ohjelma+2022%E2%80%932025+%285%29.pdf/3530e84a-aae5-03c8-3cdb-92b12f2605da

J5. City of Joensuu. (2021b). *Joensuun strategia 2021–2025, Idän houkuttelevin*. http://dynastyjulkaisu.pohjoiskarjala.net/joensuu/kokous/2021375-9-22898.PDF

Turku

T1-T3 Informants

T4. 6Aika. (2021). *Era of Cities, The joint development of the Six Cities within the Six City Strategy*. The Six City Strategy Office. https://drive.google.com/file/d/10rVW-LOKVa9fSvOBPmDYv3Rid6d4z6kS/view

T5. City of Turku. (2017a). *Toimenpideohjelma syrjäytymisen ehkäisemiseksi ja sosiaalisesti kestävän kaupunkikehityksen edistämiseksi*. https://www.turku.fi/sites/default/files/atoms/files/toimenpideohjelma.pdf

T6. City of Turku. (2018a). *Ilmastosuunnitelma 2029, Turun kaupungin kestävä ilmasto- ja energiatoimintasuunnitelma 2029*. https://www.turku.fi/sites/default/files/atoms/files/ilmastosuunnitelma_2029.pdf

T7. City of Turku. (2018b). *Strategiset ohjelmat*. https://www.turku.fi/sites/default/files/atoms/files/strategiset_ohjelmat_0.pdf

T8. City of Turku. (2018c). *Turku 2029 – pohjoisen Itämeren kiinnostavin kaupunki, Turun kaupunkistrategia 2018*. https://www.turku.fi/sites/default/files/atoms/files/kaupunkistrategia_2018.pdf

T9. City of Turku. (2020a). *Näin Turku tekee hyvää, kestävää ja parempaa kaupunkia, YK:n kestävän kehityksen tavoitteiden toteutuminen Turussa 2020*. https://www.turunseudunpuhdistamo.fi/wp-content/uploads/2020/07/turku_voluntary_local_report_sdg_web.pdf

T10. City of Turku. (2020b). *Turun kaupungin osallisuuden toimintamalli*. https://www.turku.fi/sites/default/files/atoms/files/turun_kaupungin_osallisuuden_toimintamalli_kh_6.10.2020_hyvaksyma.pdf

T11. City of Turku. (2021a). *Strategiaraportti 2020*. https://www.turku.fi/sites/default/files/atoms/files/strategiaraportti_2020.pdf

T12. City of Turku. (2021b). Turun Ilmastoraportti 2020. Turun kaupungin julkaisut 2021. https://issuu.com/turunviestinta/docs/ilmastoraportti_2020_saavutettava2

T13. City of Turku. (2021c). *Turku of Mayors – A Decade of Action, Mayor's programme 2021–2025*. https://www.turku.fi/sites/default/files/atoms/files/pormestariohjelma_2021_en_web.pdf

T14. Saikkonen, P., Hannikainen, K., Kauppinen, T., Rasinkangas, J. & Vaalavuo, M. (2018). *Sosiaalinen kestävyys: asuminen, segregaatio ja tuloerot kolmella kaupunkiseudulla*. Finnish institute for health and welfare, report 2/2018. https://research.utu.fi/converis/portal/detail/Publication/38993067?lang=fi_FI

Vantaa

V1-V3 Informants

V4. 6Aika. (2021). *Era of Cities, The joint development of the Six Cities within the Six City Strategy.* The Six City Strategy Office. https://drive.google.com/file/d/10rVW-LOKVa9fSvOBPmDYv3Rid6d4z6kS/view

V5. Berger, M. (2019). *Hiilineutraali Vantaa 2030, Selvitys tarvittavista lisätoimenpiteistä*. https://www.vantaa.fi/instancedata/prime_product_julkaisu/vantaa/embeds/vantaawwwstructure/138291_Hiilineutraali_Vantaa_2030_-selvitys.pdf

V6. City of Vantaa. (2012). *Vantaan ympäristöpolitiikka 2012–2020*. https://www.vantaa.fi/instancedata/prime_product_julkaisu/vantaa/embeds/vantaawwwstructure/126799_ymparistopoliitiikkaesite.pdf

V7. City of Vantaa. (2017a). *Valtuustokauden strategia 2018–2021*. https://www.vantaa.fi/instancedata/prime_product_julkaisu/vantaa/embeds/vantaawwwstructure/136267_Valtuustokauden_strategia_2018-2021.pdf

V8. City of Vantaa. (2017b). *Vantaan tulevaisuuskuvat, Kaupunkilaisten näkemyksiä strategiatyöhön*. https://www.vantaa.fi/instancedata/prime_product_julkaisu/vantaa/embeds/vantaawwwstructure/137655_tulevaisuuskuvat-loppuraportti-19022018.pdf

V9. City of Vantaa. (2018). *OsallistuvaVantaa, Vantaalaisen asukasvaikuttamisen toimintamalli*. https://www.vantaa.fi/instancedata/prime_product_julkaisu/vantaa/embeds/vantaawwwstructure/136964_Osallistuva_Vantaa_taitettu_valtuustoon_22.1.2018.pdf

V10. City of Vantaa. (2021a). *Asukaskyselyn tulokset, Osallistuva Vantaa -ohjelma 2022–2025*. Retrieved from https://osallistuvavantaa.fi/p/3b8y9m4ghf8b

V11. City of Vantaa. (2021b). *Kajon osallisuussuunnitelma*. https://www.vantaa.fi/instancedata/prime_product_julkaisu/vantaa/embeds/vantaawwwstructure/158101_Kajo_Osallisuussuunnitelma_strategiateeman_jory_30.4.2021_1_.pdf

V12. City of Vantaa. (2021c). *Kasvatuksen ja oppimisen toimialan osallisuus suunnitelma 2021*. https://www.vantaa.fi/instancedata/prime_product_julkaisu/vantaa/embeds/vantaawwwstructure/158098_Kason_osallisuussuunnitelma_2021_valmis.pdf

V13. City of Vantaa (2021d). *Kaupunkikulttuurin osallisuussuunnitelma 2021*. https://www.vantaa.fi/instancedata/prime_product_julkaisu/vantaa/embeds/vantaawwwstructure/158100_Kaupunkikulttuurin_osallisuussuunnitelma_2021_2_.pdf

V14. City of Vantaa. (2021e). *Kaupunkiympäristön toimialan osallisuussuunnitelma, tavoitteet ja toimenpiteet*. https://www.vantaa.fi/instancedata/prime_product_julkaisu/vantaa/embeds/vantaawwwstructure/158099_Kaupunkiympariston_osallisuussuunnitelma_tavoitteet_ja_toimenpiteet_.pdf

V15. City of Vantaa. (2021f). *Osallistuva Vantaa-ohjelma 2021–2025 LUONNOS*. Retrieved from https://osallistuvavantaa.fi/p/3b8y9m4ghf8b

V16. City of Vantaa. (2021g). *Sosiaali- ja terveydenhuollon toimialan osallisuussuunnitelma 2021*. https://www.vantaa.fi/instancedata/prime_product_julkaisu/vantaa/embeds/vantaawwwstructure/158102_Toimialan_osallisuussuunnitelma_soster_140621.pdf

V17. City of Vantaa. (2022a). *Osallistuva Vantaa -ohjelma*. Retrieved from https://osallistuvavantaa.fi/p/3b8y9m4ghf8b

V18. City of Vantaa. (2022b). *Kasvuun osaamisella ja teknologialla, Urbaania kasvua Vantaa -hankkeen julkaisu*. https://view.taiqa.com/sites/all/files/admin_files/vantaa/images/urbaaniakasvua-pdf/Vantaa_hankejulkaisuv2.pdf

V19. Huynh, Y.Y. (2020). *Vantaalaisten osallisuuden kokemukset ja näkemykset osallistumis- ja vaikuttamismahdollisuuksistaan, Kyselyn tulokset*. City of Vantaa. https://www.vantaa.fi/instancedata/prime_product_julkaisu/vantaa/embeds/vantaawwwstructure/151631_Kuntalaiskyselyn_2020_tulokset_-esitys.pd

V20. Kauppinen, S., Kesäniemi, E., Luojus, S., Lange, P. & Lönn, N. (2020). *Tarpeesta ratkaisuksi – Yhteiskehittämisen opas sosiaali- ja terveydenhuollossa*. Forum Virium Helsinki & Laurea-ammattikorkeakoulu. https://drive.google.com/file/d/1HmzFpBj2eTMBqaqtugs6IQQi9mmA4ATp/vie

V21. Laukkonen, E., Ilola, N., Kristiansson, T., Lahtinen, S., Ovaska, A., Pentinmikko, A., Sauranen, P., Varis, E. & Virta, R. (eds.). (2021). *Vastuullinen Vantaa kuuluu kaikille – YK:n kestävän kehityksen tavoitteiden toteutuminen Vantaalla 2021*. https://www.vantaa.fi/instancedata/prime_product_julkaisu/vantaa/embeds/vantaawwwstructure/158154_VastuullinenVantaa_2021.pdf

V22. Seppälä, A., Haanpää, S., Klein, J. & Juhola, S. (2017). *Kokeilujen kautta hiilineutraaleihin kaupunkeihin? Ilmastokatu-hankkeen arviointiraportt*i. Aalto University, Department of Built Environment. http://urn.fi/URN:ISBN:978-952-60-7604-1

Appendix J: Municipality data coding tree

Table J1 presents the coding tree used to code the municipality data. Codes 1–3 are based on macro-processes, their transformative outcomes (subcodes) in experimental policy engagements (Ghosh et al., 2021), and further into themes derived from EPEs questions (Schot et al., 2019) and the data.

Table J1

Coding tree

Code	Subcode	Theme
1. Building and nurturing niches	1.1 Shielding	1.1.1 Shielding mechanisms
		1.1.2 Shielding departments
		1.1.3 Funding
		1.1.4 Space
		1.1.5 Data
		1.1.6 Rules
		1.1.7 Administrative burden
		1.1.8 Who benefits
	1.2 Learning	1.2.1 Objectives
		1.2.2 Structures
		1.2.3 Risk of failure
		1.2.4 Evaluating
		1.2.5 Reporting
		1.2.6 Transferring learnings
		1.2.7 Who benefits
	1.3 Networking	1.3.1 Range of actors
		1.3.2 Network aims
		1.3.3 Coordinating network
		1.3.4 Including actors
		1.3.5 Target group needs
		1.3.6 Marginal voices
		1.3.7 Who pays and benefits
	1.4 Navigating expectations	1.4.1 Sustainability expectations
		1.4.2 Addressing expectations
		1.4.3 Change in practices
		1.4.4 Enabling creation
		1.4.5 Multiple pathways
		1.4.6 Directionality level
		1.4.7 Changing expectations
2. Expanding and mainstreaming niches	2.1 Upscaling	2.1.1 Contributions
		2.1.2 Strategies
		2.1.3 Attracting more users
		2.1.4 Benefits and drawbacks
		2.1.5 Barriers and opportunities
	2.2 Replicating	2.2.1 Enabling replication
		2.2.2 Structures
	2.3 Circulating	2.3.1 Support
		2.3.2 Intermediaries
		2.3.3 Structures
	2.4 Institutionalising	2.4.1 Processes
		2.4.2 Mechanisms
		2.4.3 Driving actors
		2.4.4 Intermediaries
3. Opening up and unlocking regimes	3.1 De-aligning and destabilizing	3.1.1 Unlocking path dependencies
		3.1.2 Addressing resistance
	3.2 Unlearning and deep learning in regimes	3.2.1 Questioning
	3.3 Strengthening regime-niche interactions	3.3.1 Support
	3.4 Changing perceptions of landscape pressures	3.4.1 New expectations

Appendix K: Municipalities building and nurturing niches

The experimental policy engagements municipalities engaged in building and nurturing niches and the challenges the representatives of municipalities recognized when engaging in them are presented in the following tables. Table K1 presents shielding, Table K2 learning, Table K3 networking, and Table K4 navigating expectations related EPEs and challenges.

Table K1

Shielding related experimental policy engagements and challenges

Theme	Experimental policy engagements and challenges	Files
Shielding mechanisms	Municipalities were seen to want to engage with experiments that have possibilities for continuity.	H1
	Municipalities were seen to offer several modes of shielding.	H1–2, H26, J2, T3
	Municipalities got shielding and external resources in many ways.	H2, T2, T11, V5
	Helping companies were seen as one important part of shielding experiments.	H5
	Lack of time or people to do the job related to shielding was seen to limit the experiments municipalities could provide shielding for.	J1, T1, V1
	Municipalities were seen not to be able to engage in shielding experiments that improve private business' profit margins.	V3
Shielding departments	Forum Virium Helsinki offered help for the experiments to contact right persons in the city to obtain permits.	H1
	Municipalities had special offices, personnel, innovation platforms, and/or city owned companies for shielding experiments.	H1–2, H5,H7, H12, H21, H26, T1, T3–4, V2–4
	Managing several experiments was seen to provide synergy benefits and learnings on how shielding could be done more efficiently.	H1, H21, T1, V3
	Centralized models were not always known outside the project office.	H1, T1, V3
	From the case municipalities Helsinki had the most advanced system for shielding experiments.	H3, H26
	Turku was following Helsinki by starting to develop testbed for experiments.	T2
Funding	Municipality strategies and funding instruments were seen as guiding factors in determining which experiments were engaged with.	H1–4, J1, T1, V3
	Municipality process for providing funding to experiments was seen to be tedious, require time and be unfit for very agile experimenting.	H1–4, H14, J1, T1, V3
	Lack or limits of funding were seen to limit the experiments municipalities were able to provide shielding for.	H1–2, T1, V2
	The practice to assess scalability of the experiments in advance and chain multiple funding instruments after another was seen to limit the experimental nature of the experiments.	H1, T1
	Funding instruments were seen not to be suitable for very agile experimenting such as changing plans if something did not work.	H2
	Separate funding was seen as a requirement for experimenting as it was seen to bring some security to experiments.	J1, T1–2, V2
	Municipalities offered funding for stakeholder experiments.	J4
	Funding instruments were seen not to fit very well with long-term construction projects.	T1
	Turku had set a goal to explore the possibilities of combining crowdfunding and municipality funding.	T10
	It was seen that many funding instruments required taking social justice into account.	V2

Table K1

Shielding related experimental policy engagements and challenges (continued)

Theme	Experimental policy engagements and challenges	Files
Space	Municipalities offered spaces for trial and error for experiments.	H1, H5, H7, H12, H24, H26, T4, T11, T14, V2, V4
	Municipalities were seen as space for experimenting national level policies.	H9, V3, T11
	Fitting also into challenging construction areas was seen to be a need for low carbon experiments.	V1
	It was seen that experiments should be able to fail, but city rules did not always allow this kind of space to exist.	V2
Data	Data access and platforms were offered for experiments.	H1, H7, T1, T4, T8, T11, V4
	Offered data may not been picked up and utilized as the municipality would have hoped for.	T1
Rules	Experimental culture could be recognized and there were some special rules providing flexibility for experiments.	H1, H4, H25, T1, V1
	Rules and limiting experiments were seen to prevent better results and learnings.	H2
	Helsinki had placed a person to guide the permit process into the project team to help the experiment.	H3
	Experiments had to follow municipality rules without exceptions.	H3, H5–6, H14, T1, V1–2
	Municipality rules were seen as possibly hard to understand.	H3, H5–6, T1, V1–2
	Companies taking part in experimenting wished to have spaces with minimal regulation to easily test new solutions.	H21
	The process to allow flexibility for experiments was seen as hard and rare.	V1
Administrative burden	Helsinki had hired a consultant to do the work related to comparing, monitoring, and supporting low carbon solutions.	H2
	Low carbon solutions were seen to be hard to compare, monitor and support with the limited resources municipalities had.	H2, T3, V1
	Project funding was seen to take care a lot of the administrative burden that comes with experiments.	J1, V2
	The administrative burden related to applying funding was seen as a work that was not covered by the project funding.	J1, V2
	Funding instruments and city policies were seen to create administrative burden.	T1–2
Who benefits	Municipalities had to take social justice into account in everything they did as a part of the municipalities' legally mandated role as well as a requirement for many funding instruments.	H1–2, T1–3, V1–3
	Dual goals in experimenting were seen to be present in for example positioning the experiment in more disadvantaged neighborhood.	H1–2, T1–3, V1–3
	Municipalities had aims to ensure that small and medium-sized companies could have also participated.	T13

Table K2

Learning related experimental policy engagements and challenges

Theme	Experimental policy engagements and challenges	Files
Objectives	Learning was seen as one main goal of experimenting and something that happened in the experimental process.	H1, H4, H22, H26, J2, T3
	There was positive attitude towards learning.	H1, H4, J2, T3
	Challenges and learning from them were seen as a crucial part of the experimental process.	H1, H3
Structures	There were support structures to promote learning in experiments and continuous work was done to develop them further.	H1, H6, H19, H22, H26, T2, V3
	Support structures for learning were identified as important part of the experimental process.	H3, H22, H26, T1, T3, V1–2
	Structures to promote learning were not always recognized by people working outside the project office.	H3, T1, T3, V1–2
	Support structures for learnings were seen as important to help experiments survive challenges.	H1, H3
	It was seen that in practice it was easier to focus on what actors are doing rather than question frames and assumptions of structures and activities.	H2–3, V3
	Frames and assumptions of structures and activities were questioned.	H2–3, V3
Risk of failure	Municipalities had personell to work on reducing the risk associated with new operations.	H7, T4, V4
Evaluating	Experiments were seen to be assessed first time already in the process when they were being chosen to be engaged with.	H1, T7
	Feedback was collected from all participants during and after the process.	H14, H22
	The nature of experimenting, possibility to fail, might have been forgotten when evaluating experiments.	J1, T1, T3
	The notion that something did not work was seen to sometimes be a good enough learning from failed experiment.	J1, T1, T3
Reporting	Reporting was seen as one way to distribute, transfer, and evaluate learning.	H19, H26, J1, V2
	It was seen as important to take the learnings outside the report and into practice.	H19, J1, V2
	It was seen that in practice possibly important learnings from failed attempts were not reported so well due to lack of resources.	J1, T1, T3
Transfering learnings	There were attempts to share learnings by means of networking, providing data for open access, and communicating them outside the project team and even outside the city.	H1–2, H4–5, H19, J1, T1, V1, V3
	Learnings were seen to be utilized in other projects.	H5, H19, J1, V3
	Models and policies were seen to be created from experiment learnings.	H5, J1, V3
	Utilizing learnings was seen as one goal of the experiments.	J1, T3, V3
	Using the gathered learnings was seen to be possibly difficult.	J1, T3, V3
	It was seen that some learnings were left only with certain project workers and if the municipalities do not succeed in keeping the workers learnings and silent knowledge were lost with the person.	H2, H19, J1, T1, V1, V3
	Municipalities tried to utilize same project personnel in multiple projects to utilize their silent knowledge gathered in previous experiments.	H2, H19, J1, T1, V1, V3
Who benefits	The experiment participants (especially participating companies) benefitted from the learnings.	H26

Table K3

Networking related experimental policy engagements and challenges

Theme	Experimental policy engagements and challenges	Files
Range of actors	Municipalities networked with each other nationally and internationally.	H1–2, H4, H7, H9, J1, J4, T3–4, T8, V2–4
	Nationally municipalities networked with each other mainly in multi municipality projects.	H1–2, H4, J1, T3, V2–3
	Bigger projects were seen to offer space for municipalities to network with each other.	H1–2, H4, J1, T3, V2–3
	Different departments of the municipality cooperated with each other, with municipality owned project actors, affiliated companies and residents.	H1–2, H4, J1, T3, V2–3, V11, V20
	Having right actors in the experiment was seen as important but not always easy.	H1, J1, V2
	Cooperation was seen to be challenging if there are too many actors.	H2
	Having different actors was seen to make networking harder but results better.	H2, H22
	Lack of resources in municipality departments was seen to inhibit taking part in networking.	T2
	New forms of networking included for example innovation partnership and climate partnership between the municipality and private business.	T11, J2
Network aims	Experimenting was seen to create neutral and safe space, make exchanging ideas easier, and create potential for new networks.	H1
	Continuing cooperation was seen possible even after the experiment if it was beneficial to all parties.	H1
	Committing actors into the process was seen as vital part of successful experiment.	H1, T6
	Networking was seen as important for expanding and mainstreaming niches.	H1, T6
	Shielding related experimental policy engagements were seen to require networking.	H1–2
	Networking actions were done mainly to create niches and accelerate them.	H1–2, H4, H26, J1, T3, T6, V2–3
	Learning past only the project team was seen to require networking such as meetings to share learnings.	H2, H6, H26
	It was seen that networking makes experiments possible.	H4, H26, J1, V3
	Networking was used to address challenges in the experiment process.	H5
	Networking was used to help municipality outside actors to understand the municipality protocol.	H5, H26
	Networking was used to understand the needs of others.	H5, H26, T10
	Networking was used to find suitable experiments.	H5–6, H26, T2
	Networks were seen as positive.	H25, J1, V3
	Learning to network better was seen as important.	J1
	The aims of networking were seen to differ between actors and sometimes participating company saw networking only as a business transaction.	J2
	Network connections were seen to develop into deeper connections even if it was not the initial aim of networking.	J2
	Cooperating was seen as particularly important in questions like lowering embodied energy by addressing on-site deliveries.	V1
Coordinating network	Municipality role was also seen to include connecting other actors with each other.	H1
	Getting familiar with the actors was seen as important for mutually beneficial networking in experiments.	H1

Table K3

Networking related experimental policy engagements and challenges (continued)

Theme	Experimental policy engagements and challenges	Files
Coordinating network (continued)	Networking was done for example in workshops and meetings.	H1–H2, H7, H26, T4, V4, V11
	Municipalities and municipality owned actors were coordinating the networking.	H1, H25–26, T3, T10, V11, V22
	Municipality departments were often experiment owners.	H1, T3
	Project offices, innovation agents, and special departments were seen as an intermediary that supported networking between the municipality departments.	H3, H7, H17, H21, T10, V9, V11
	Municipality actors did not always know what they were able to decide or promise when networking.	H6
	Municipalities had goals to develop the ways different participants were included in the process.	H10, H12, H17, T7, T10–11, T13, V9, V13
	Diverse interests of participants were seen to possibly yield conflicts or tensions.	H21
	Cooperating and communication were seen as important in networking.	H26, J1
	Experimenting was seen to require networking between the municipality departments.	J1
	Navigating expectations was seen as important to get the right parties involved.	J1
	Taking social sustainability into account was seen to require networking between professionals in different fields.	J1
	Getting experiments going was seen to require more when many parties were involved.	J2
	Big size of municipality was seen to make networking harder as the messages and actors needed to be more deliberate as everything happening could have not been communicated for everyone.	T1
	Some experiments were seen to face initial resistance though the initial resistance was also seen to turn around in some cases.	T1
	In Turku, city feedback service was used as a tool to collect feedback also from the experiments.	T1, T9, T11
	Problems in shielding were seen to inhibit networking.	T2
	Coordinating networking was seen important to get the most important messages through and to not burden project workers.	T2
	Schedules, problems in communication, procurement act, lack of resources, and key personnel changes were seen to create challenges for bringing the right actors together.	T2–3, V2–3
	Organizing network coordination was seen as important.	T5, V16
	Municipalities networked by sparring, research and studies, and procurement of experiments to support innovation.	T12
	Lack of uniform indicators and clear process for assessing participation was recognized.	V13
Including actors	Including the network for choosing the experiments was seen to increase the commitment of actors.	H1
	Some ways of including actors in the experiments (such as inviting residents to plant flowers) failed to address procedural justice adequately.	H1, H4, J1
	It was seen important to include actors who can provide some value for the experiment by being part of it.	H1, H7, H17, T4, T6, V3–4
	Municipalities saw that to make lasting and large-scale impact and low carbon solutions more prevalent, residents should be part of the process to make the transition just.	H2, H24, H26, T14, V3
	Municipalities thought about ideal actors in the planning phase.	H3, T10

Table K3

Networking related experimental policy engagements and challenges (continued)

Theme	Experimental policy engagements and challenges	Files
Including actors (continued)	Residents appreciated easy networking opportunities and municipalities tried to offer them to get more actors involved.	H3, V10
	Active local partners were seen to help experiments to succeed.	H3, H11, J1, T6
	Participants were seen to value more the workshops with different kind of actors as they learned more.	H20
	Some potential actors were not interested in and did not take part in the experiments.	J1, T2, V3, V10
	Transparency and keeping different actors (included in the process) aware of the process was seen as important for not only the experiment but also future collaborations.	J5, V2–3
	It was seen that if right parties did not get involved the goals of the experiment had to be reevaluated and possibly changed.	T2
	Facing challenges and delays were seen to make it harder to get actors commit into experiments.	T2, V3
	Different operating cultures were seen to create possible clashes between actors.	T3, V3
	Potential actors were seen to decline participation for reasons like lack of resources and not seeing the experiment important enough.	T3, V3, V10
	With construction project it was seen to be hard to get the residents to participate as the actual residents were often not known in advance and the neighbors often did not care unless they perceived potential disadvantage for them.	V1
	The city process to find actors was seen to have challenges in finding new kind of actors.	V3
Target group needs	Having profound dual goals were seen to require working together with departments responsible for the social services etc. to for example reach and serve the local people.	H1
	Team spirit and getting participants excited was seen as important to participate residents.	H2
	Keeping also future residents needs in mind was seen as important.	H7, T4, V4
	It was seen that target group needs should have been included in more ways than just level of consulting.	H8
	Networking with residents was seen as a way to take social justice into account.	H8, H10, J1, T9
	Municipalities had goals, programs and actors to participate residents and resident groups and empower them.	H11, H19, J3–5, T10, T13, V7, V9, V12, V15,V21
	Networking with residents in the early phases of experimenting was seen to be challenging.	H19, J1, T1, T10, V10
	Living lab was one way to include actors and take target group needs into consideration in a user-centered innovation.	H22
	Some examples of participating residents in the process did very little in terms of addressing social justice.	J1
	Inviting residents to take part in planting trees was one example of low level of social justice in networking with residents.	J1
	Making experimenting accessible for everyone was seen as challenging, for example in Turku digital platforms were utilized in networking with residents but not everyone could find them.	J1, J3, T2
	Residents were many times taken into the experiment process at the very end phases when the concept was already finished and this was seen sometimes to result in frustration by the residents.	J1, T1
	It was seen hard to motivate residents to participate without the knowledge of what the experiment will precisely be.	J1, T1

Table K3

Networking related experimental policy engagements and challenges (continued)

Theme	Experimental policy engagements and challenges	Files
Target group needs (continued)	Target group felt that municipality took the target group needs and opinions poorly into consideration when making decisions.	J3
	Target group participants felt that participating in developing their own district was difficult and/or time-consuming.	J3, V19
	Municipalities had legal obligations to participate residents and these obligations applied in some experiments.	T1, T7, T10, V9, V15, V17
	The efforts to include experimental policy engagement target group fell sometimes short on addressing procedural justice.	T2
	Social justice was seen as important part of the climate work and experimenting.	T2–3
	Resident needs were included for example by utilizing resident jury and participative budgeting.	T10, V2–3
	Target group needs could have been included in the process by participation in decision making, planning, and/or action phase of the experiment.	T10, V9, V15, V17
	In construction projects particularly participating residents was seen to be difficult as the future residents of the buildings are often not known beforehand.	V1–2
	Neighborhood was seen often only get interested if they perceived some kind of disadvantage for themselves.	V1–2
	Need to develop ways to include the needs of the target groups in the experiments was seen as something that needed to be developed.	V2–3
	Including the needs of the experimental policy engagement target group was seen to become even more important in the future.	V2–3, V8–9
Marginal voices	Marginal voices were specially involved in certain projects.	H13, J5, T2, T7, T9–11, V2, V12, V14-17, V21
	Turku had participation network model that helps them to participate needs of different (for example socially vulnerable) groups into the experiments.	T1
	Municipalities had special councils to help take different socially vulnerable groups into account and participate them into the experiments.	T1, T9–11, V11–12, V14–17, V21
	Dedicated people were working with different vulnerable groups.	T3, T7, T9–11, V3, V14–17
	Working with different kind of resident groups was seen as important.	T3, V3, V11–12, V14–17, V21
Who pays and benefits	In many cases municipalities paid for and benefitted from the learnings and other experiment participants benefitted also.	H18, H26
	Municipalities had demolished buildings to address social segregation and build more environmentally friendly housing. This forced some vulnerable groups to move to other parts of the municipality as they no longer could afford to live in the area. The residents of the demolished buildings were not always taken into account participated into these decisions.	V1
	The possibility of social consequences raised a question if actual social justice is something that can be experimented with as it was seen that the risks could not have fallen on to vulnerable groups.	V2–3

Table K4

Navigating expectations related experimental policy engagements and challenges

Theme	Experimental policy engagements and challenges	Files
Sustainability expectations	Examples of dual goals may have quite low-level examples of social justice in them (e.g., renting a space to have birthday parties is accessibility in a way but not as profound as accessibility to low carbon housing itself).	H1, H4, J1
	In the low carbon projects the environmental expectations were often seen as the starting point and possible social justice side was kind of an afterthought.	H3
	Municipalities expected experiments to do something novel and find best possible solutions to implement.	H4, V1
	Seeing the connection between low carbon housing and social justice was sometimes hard for the officials working with experimentation as their expertise is more in the environmental side.	H6
	Municipalities had carbon neutrality goals and experimenting was seen as one way to work towards these goals.	H7, H9, H11, H14, H16–17, H22, J4–5, T4, T6, T12, V4–6, V21
	Municipalities expected experiments to contribute to municipality strategy goals.	H7, T2, T4, T7, V4
	Municipalities aimed to be forerunners in active, inclusive, and innovative climate work.	H17, J4
	Companies taking part in experimenting paid more attention to means than the ends.	H21
	Municipalities had expectations such as content targets and meters to evaluate the realization of these targets.	H23, T3, V6
	Carbon emission reduction expectations were seen as challenging and hard to measure.	H25, V2, V22
	It was seen that the sustainability expectations should be about moving things forward rather than solving these complex issues entirely.	T1
	There was not one common model for evaluating expectations and the ways differed between experiments.	T1
	It was seen that the social side was not always expected to be so apparent in low carbon experiments as the social side had their own experiments and projects.	T3
	Because municipalities needed to evaluate the realization of sustainability expectations sometimes some kind of certificates were used to make someone else monitor these expectations.	V1
	Expecting impacts in forms of new procedures and practices was seen as smart expectation in terms of sustainability.	V2
	It was seen that project leader should have strong subject matter knowledge to not leave the vision and practice into hands of others.	V18
Addressing expectations	The experiment goal was seen to learn as much as possible.	H1
	Experiments were seen to be something that had possibility to fail.	H1, H26, V8
	Investor expectations were taken into account.	H2
	Municipalities expected to do something permanent.	H4
	Impact and scalability were seen as something that everyone expected and wanted.	H4, T2, V2–3
	Each actor was seen to have different expectations, interests, and motivations for participating.	H26, V3
	Navigating expectation was seen as important to make future collaborations possible.	T2
	Making clear the nature of experimenting and the possibility to fail was seen as important.	V2
	Avoiding empty promises was seen as important for future collaborations.	V2

Table K4

Navigating expectations related experimental policy engagements and challenges (continued)

Theme	Experimental policy engagements and challenges	Files
Addressing expectations (continued)	Acting neutrally and transparent and preparing everyone to compromise was seen as important.	V3
Change in practices	Municipalities wished to make the experiments normal municipality activity and continue experiments past the experiment duration.	H2
	Havin long enough projects was seen to be important to have impacts seen during the project to convince that the practice should be continued beyond the experiment.	H2
	It was seen that someone should have been responsible for the continuity.	H2
	Municipalities expected things to take time to implement even if they were already planned.	H2
	Municipalities had adopted new development culture.	H7, T4, T7, V4
	Municipalities had goals to develop their practices to strengthen participation, ownership and success.	H22, J5, T7
	Even if something was seen as good it necessarily did not move forward even if it was the aim of the municipality and other actors.	T3
Enabling creation	Keeping everyone open minded was seen as important for finding something actually new.	H1
	Municipalities expected project partners to add some value to the experiments.	H1
	As the experiment focus is to find something new it was seen that the experiments should not be all about scalability.	H5
	Sometimes something that has been done for a long time already was called an experiment.	H25, T1, V22
	Navigating expectations was seen to include telling participants what an experiment actually is so that everyone is on the same page.	T2
Multiple pathways	The focus was often in a single chosen solution rather than exploring alternative pathways as multiple pilots were needed after the experiment to scale up.	H5
Directionality level	It was seen that municipalities needed to follow up with the experiments.	V1
	Municipalities hoped sometimes that the experiments would have just spread on their own.	V2
	Making municipality role clear was seen as important when navigating expectations.	V3
Changing expectations	If the expectations were not met it was seen that municipalities should have thought reasons for this and possibly changed expectations.	H2
	Being able to change one's expectations during experimenting was seen as important because the found best solution might differ from the expected result.	H5–6, J1

Appendix L: Municipalities expanding and mainstreaming niches

The experimental policy engagements municipalities engaged in expending and mainstreaming niches and the challenges the representatives of municipalities recognized when engaging in them are presented in the following tables. Table L1 presents upscaling, Table L2 replicating, Table L3 circulating, and Table L4 institutionalizing related EPEs and challenges.

Table L1

Upscaling related experimental policy engagements and challenges

Theme	Experimental policy engagements and challenges	Files
Contributions	This was done through means of planning, guidance, examples, and incentives.	H11
	Municipalities developed or aimed to develop public procurements in such a way that they supported scaling of new low carbon solutions.	H11, V5
	Helsinki had experimented with two-phased agile piloting model in Jätkäsaari.	H20
Strategies	Helsinki had experimented with two-phase agile piloting model to upscale experiments.	H1
	Upscaling experiments was seen to include several decisions for the actors starting from whether the experiment was something worth upscaling to how the funding could have been organized and who could have continued the experiment.	H2
	Upscaling developed actions was seen as important.	T5
	Project offices were seen to be able to help with upscaling as they were able to see comparable and quantifiable results.	V3
	It was seen that upscaling could not happen only from top down.	V3
Attracting more users	Municipalities aimed to upscale by communicating the results further.	H2
	The abundance of information and thus getting one's message through was seen as a challenge in upscaling the experiments by communicating the results further.	V3
Benefits and drawbacks	It was seen that when the experiments are brought further or upscaled the social justice aspect becomes more important than in building and nurturing niches.	H3
Barriers and opportunities	If an experiment had been very dependent on single project worker, it was seen to make upscaling harder.	H2
	Lack of resources was seen to limit upscaling activities.	H2, H19
	Municipalities aimed to have favorable conditions to promote the success of their companies, universities, and residents.	H7
	Municipalities did not always recognize the reasons why something might not be upscaled and it was seen to rather just happen.	T3
	Upscaling was seen not to suit the municipality role if it meant increasing profit margin of some company.	V3

Table L2

Replicating related experimental policy engagements and challenges

Theme	Experimental policy engagements and challenges	Files
Enabling replication	Municipalities replicated and planned to replicate successful experiments into other contexts.	H1, T2
	Municipalities replicated also only parts of the experiments such as models for calculating carbon emissions.	J1
	Municipalities communicated the results so that other areas or municipalities could replicate them.	J1, T2, V2–3
Structures	Helsinki agile piloting model had been replicated to other municipalities internationally.	H1
	Replicating experiment was seen to require translation and learnings between different contexts and neighborhoods.	H1, H3
	Supporting spaces where experiment actors shared what has worked was seen as one way to enable replicating as someone else could have picked it up and replicated it.	H2, J2
	Including local partners was seen to help translating experiments into different contexts.	H3

Table L3

Circulating related experimental policy engagements and challenges

Theme	Experimental policy engagements and challenges	Files
Support	Circulating was seen to help utilizing shared ideas between different types of experiments.	H1, H26, J1
Intermediaries	Helsinki agile piloting model and intermediary Forum Virium Helsinki supported circulation of ideas, recourses and more between experiments.	H1, H26
	Project offices did and supported circulation.	V3
Structures	Municipalities utilized same project workers in multiple experiments to circulate resources and know-how.	J1
	Taking account the legal role of the municipality was seen as important in circulating, as not every experiment could have been done the same way. For example, if the experiment was related to health care and social services municipalities needed to keep in mind that these are legally mandated operations and thus cannot be failed to deliver.	V3

Table L4

Institutionalizing related experimental policy engagements and challenges

Theme	Experimental policy engagements and challenges	Files
Processes	Having longer-term projects was seen beneficial for institutionalizing.	H2
	It was seen as important to plan institutionalizing from the beginning of the project and thus plans to institutionalize were often in place before it was known whether the experiment worked or not.	H4, V2
Mechanisms	Municipalities had attempted to institutionalize niche rules by for example providing information about applicable measures, making things permanent, and making different policies such as climate budgeting.	H2, H4, H6, J1, T1, T11, T13 V1–3, V21
	One example of institutionalizing is including energy counseling into the building control services where people planning renovations had to go anyway.	H3
	It was seen that multiple pilots would have been needed after the experiments to institutionalize something.	H5
	Participatory budgeting and citizens' panels were seen as examples of institutionalizing the act of doing experimental policy engagements.	H7, T4, T11, V4
	Municipalities had plans to institutionalize but these plans required resources that municipalities did not always prioritize.	J1–2, T3, V2
	Municipality strategies, climate programmes, ecosystem agreements etc. were seen to aim to implement and institutionalize activities.	J1, T1, V1–3
	Actual institutionalization was seen to take time in the slow municipality process.	T2
Driving actors	In climate actions municipalities recognized the rush to institutionalize practices rather sooner than later.	H3
	Strong subject matter knowledge was seen as important factor in deciding what to institutionalize.	V1
Intermediaries	Municipalities had departments accountable for institutionalizing experimental processes as a part of municipality conduct.	J1, T1, V2

Appendix M: Municipalities opening up and unlocking regimes

The experimental policy engagements municipalities engaged in expending and mainstreaming niches and the challenges the representatives of municipalities recognized when engaging in them are presented in the following tables. Table M1 presents de-aligning and destabilizing in regimes, Table M2unlearning and deep learning in regimes, Table M3 strengthening regime-niche interactions, and Table M4 changing perceptions of landscape pressures related EPEs and challenges.

Table M1

De-aligning and destabilizing in regimes related experimental policy engagements and challenges

Theme	Experimental policy engagements and challenges	Files
Unlocking path dependencies	National level measures and policies were seen as an important part of de-aligning and destabilizing in regimes.	V1
Addressing resistance	Resistance to change or not seeing the need for a change was seen to inhibit de-aligning and destabilizing in regimes.	J1
	Some of the resistance for change was seen to come from the regime companies as de-aligning and de-stabilizing was seen to possibly affect profits of regime companies.	V2

Table M2

Unlearning and deep learning in regimes related experimental policy engagements and challenges

Theme	Experimental policy engagements and challenges	Files
Questioning	It was seen that resistance to change may inhibit unlearning in regimes.	J1

Table M3

Strengthening regime-niche interactions related experimental policy engagements and challenges

Theme	Experimental policy engagements and challenges	Files
Support	Regime-niche interactions were attempted to strengthen by sharing the experiment data with the regime.	V2
	Regime-niche interactions were seen as important and something that could be strengthened and supported by different activities such as policy instruments.	V2

Table M4

Changing perceptions of landscape pressures related experimental policy engagements and challenges

Theme	Experimental policy engagements and challenges	Files
New expectations	Climate perspective was taken into account in decisions and competitive tendering.	H17, J5, T13
	It was seen that municipalities should be very informed about the subject matter to be able to require the latest technologies.	V1